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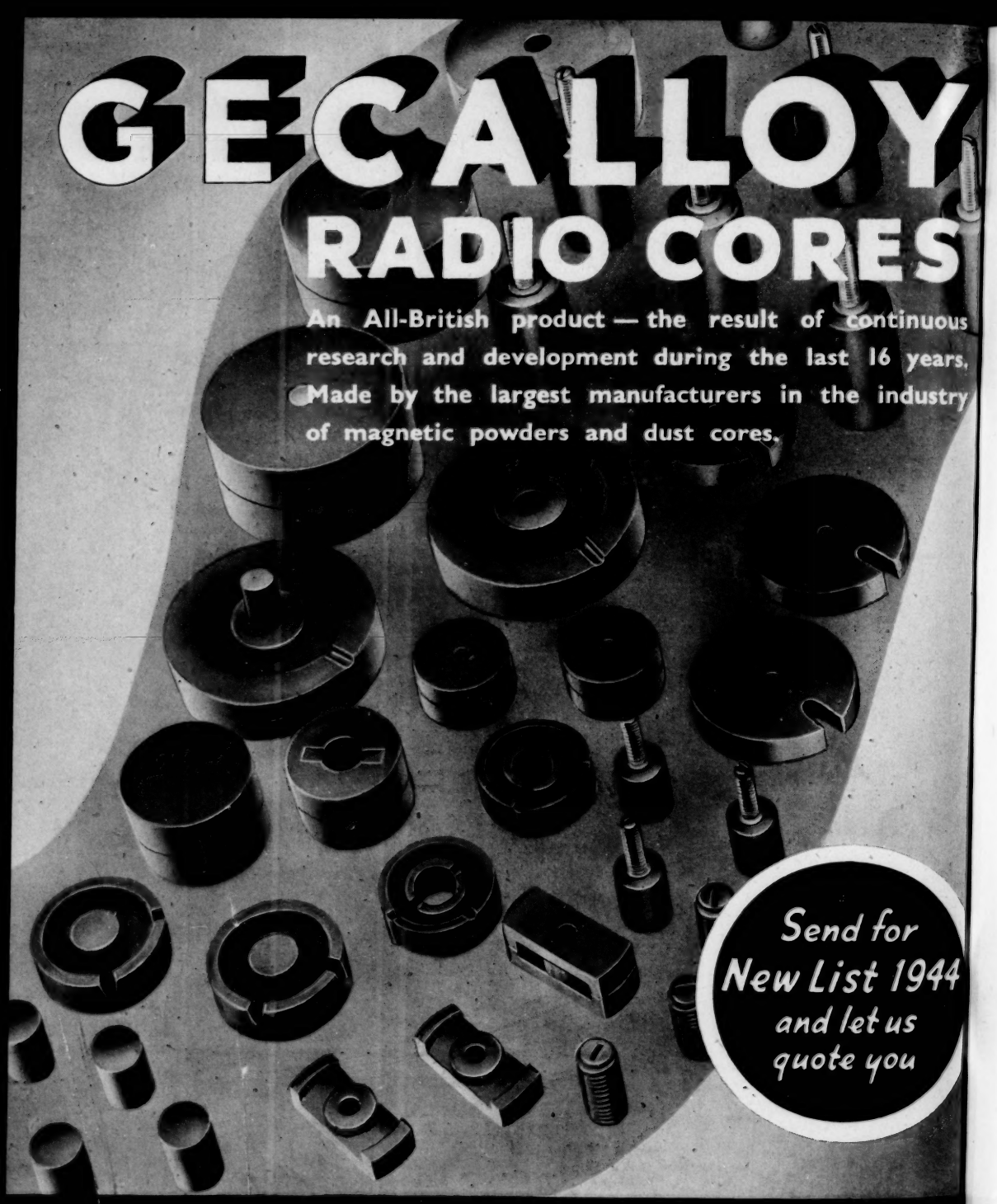
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WIRELESS ENGINEER

Editor HUGH S. POCOCK, M.I.E.E. Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E.

VOL. XXII AUGUST, 1945 No. 263

The Radiation Resistance of a Mistuned Dipole Aerial

THE April Editorial was devoted to the calculation step by step from fundamental principles of the radiation resistance of a half-wave dipole aerial. We confined ourselves to the case in which the aerial is tuned, and we assumed that this corresponded exactly to the length being half a wavelength. This is, of course, not strictly true, the actual resonant length differing from the half wavelength by a small amount depending on the ratio of the radius to the length. Adopting the same relatively simple approximate methods it is possible to calculate the radiation resistance when the dipole is not tuned.

As an example we shall consider first the case in which the wavelength is four times the length; i.e., the frequency half the resonant frequency. Taking the current at the mid-point as unity, the current at a distance x above or below the mid-point will be

$$\sqrt{2}\cos\left(\frac{x+l/2}{l}\cdot\frac{\pi}{2}\right)=\sqrt{2}\cos\left(\frac{2x}{l}+1\right)\frac{\pi}{4}$$

The phase difference ϕ between the radiation from this point and that from the mid-point in the direction shown (Fig. 1) will be $\frac{2\pi x}{4l}\cos\theta$. The effective component of Il in this direction due to the element dx will be

$$\sqrt{2}\cos\left(\frac{2x}{l}+1\right)\frac{\pi}{4}\times\cos\left(\frac{2\pi x}{4l}\cos\theta\right)dx$$

Expressing this as the sum of two cosines integrating from 0 to $l/2$ and doubling the result to allow for the other half of the aerial, we obtain

$$\frac{4\sqrt{2}\,l}{\pi}\times\frac{\cos(45^\circ\cos\theta)-0.707}{\sin^2\theta}$$

as the effective value of Il in various directions. In the equatorial plane $\theta=90^\circ$, and we have

$$\frac{4\sqrt{2}l}{\pi}\times 0.293 = 0.5275l$$

0.5275 is simply the mean value of the current along the dipole when that at the centre is taken as unity. The above expression may be written

$$\frac{0.293\sqrt{2}\,\lambda}{\pi}\times\frac{\cos(45^\circ\cos\theta)-0.707}{0.293\sin^2\theta}$$

in which the variable right-hand factor is unity when $\theta=90^\circ$. Instead of varying simply as $\sin\theta$, the value of $\mathfrak{E}$ at a given distance will be proportional to

$$\sin\theta\times\frac{\cos(45^\circ\cos\theta)-0.707}{0.293\sin^2\theta}$$

and the energy density in space is proportional to this squared. The energy contained in the elemental zones of the spherical shell, the volumes of which are proportional to $\sin\theta$, is therefore proportional to

$$\frac{[\cos(45^\circ\cos\theta)-0.707]^2}{0.293^2\sin\theta}$$

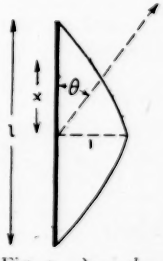

Fig. 1. $\lambda = 4l$.

This is the expression that must be integrated from 0 to π instead of $\sin^3\theta$ to find the energy in the whole shell. As before, this is easily done by calculating its value for a number of values of θ between 0 and 90° and applying Simpson's rule. This gives 0.416 whereas $\sin^3\theta$ gave 0.424; hence the effect of phase difference in this case is to reduce the radiation resistance to 0.985 of its calculated value.

Since the mean current is 0.5275 of that at the mid-point, the radiated power, neglecting phase difference would be*

$$(0.5275\ Il/\lambda)^2 \times 789 = 13.7\ I^2$$

The effect of phase difference is to reduce the radiation resistance from 13.7 to 13.5 ohms, a change of less than 2 per cent.

Let us now consider a case in which the frequency is above the resonant value; we take as an example the case in which it is 1.5 times the resonant value, and therefore $l = 3\lambda/4$. From Fig. 2 it is seen that the current at a distance x above or below the mid-point is equal to $\sqrt{2}\cos\left(\frac{x}{l} - \frac{1}{6}\right)\frac{3\pi}{2}$, if the current at the mid-point is taken as unity, and the phase difference $\phi = \frac{3\pi}{2} \cdot \frac{x}{l} \cdot \cos\theta$.

Adopting the same procedure as before, the effective value of Il in various directions is found to be

$$\frac{1.707\sqrt{2}\,\lambda}{\pi} \times \frac{\cos(135^\circ\cos\theta) + 0.707}{1.707\sin^2\theta}$$

in which the variable factor is unity when $\theta = 90^\circ$.

By taking the formula

$$\frac{[\cos(135^\circ\cos\theta) + 0.707]^2}{1.707^2\sin\theta}$$

and applying Simpson's rule to a number of calculated values the mean is found to be 0.339 instead of 0.424. Hence the effect of phase difference at this higher frequency is to reduce the radiation resistance to $0.339/0.424 = 0.8$ of its calculated value.

The mean current along the aerial is 1.024 of the mid-point current, and, neglecting phase difference, the radiated power would be

$$(1.024\ Il/\lambda)^2 \times 789 = 467\ I^2$$

The effect of phase difference is to reduce the radiation resistance from 467 to $467 \times 0.8 = 374$ ohms, a reduction of 20 per cent.

Anti-Resonant Dipole

As a third example of a somewhat different type we take the case in which the frequency is twice the resonant frequency, and therefore $\lambda = l$. This might be called the anti-resonant condition, and, apart from losses, the current at the mid-point would be zero (Fig. 3). Taking the current at its maximum point as unity, the current at a distance x above or below the mid-point is equal to $\sin(2\pi x/\lambda)$, and the phase difference $\phi = (2\pi x/l)\cos\theta$. By the same procedure as before the effective value of Il in various directions is found to be

$$\frac{2l}{\pi} \times \frac{\cos(\pi\cos\theta) + 1}{2\sin^2\theta}$$

in which the variable factor is unity when $\theta = 90^\circ$.

By taking the formula $\frac{[\cos(\pi\cos\theta) + 1]^2}{4\sin\theta}$ and applying Simpson's rule to a number of calculated values the mean is found to be 0.264 instead of 0.424. Hence, the effect of phase difference is to reduce the radiated power to 0.264/0.424, i.e., 0.625 of the value calculated neglecting the phase difference. If the r.m.s. value of the current is 1 ampere at its maximum point, the mean current $I = 2/\pi$ and since $l = \lambda$, $I^2 l^2/\lambda^2 = 4/\pi^2$ and the radiated power neglecting the phase effect is $789 \times 4/\pi^2 = 320$ watts. Allowing for the phase effect this is reduced to $320 \times 0.625 = 200$ watts. This cannot be expressed as a radiation resistance in the same simple manner as was employed in the other cases, because we have assumed as an approximation that the current at the feeding point is zero.

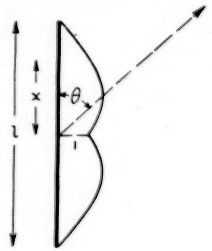

Fig. 2. $\lambda = 4l/3$.

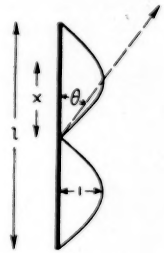

Fig. 3. $\lambda = l$.

The Dipole as an Open-Circuited Line

In the Editorial of December, 1944, we showed that, regarded as an open-circuited line, the capacitance and inductance per unit length at resonance are given approximately by the formulae

$$C = \frac{1}{4\log_e l/d} \cdot \frac{1}{9 \times 10^{11}}\ F$$

and $L = 4\log_e l/d \cdot 10^{-9}\ H$

where l and d are the length and diameter

* *See* p. 155.

of the dipole. Hence $\sqrt{(L/C)} = 120 \log_e l/d$. If we put l/d equal successively to 250, 2,500, and 25,000 this gives for $\sqrt{(L/C)}$ the values 662.4, 939 and 1,212 ohms.

Now the impedance of an open-circuited line of length l_1 is given by the formula

$$Z_1 = Z_0/\tanh Pl_1$$

where

$$Z_0 = \sqrt{\frac{R+jX}{jB}} = \sqrt{\frac{L}{C}} \times \sqrt{\left(1 - j\frac{R}{X}\right)}$$

$$= \sqrt{\frac{L}{C}} \times \left(1 + \frac{R^2}{4X^2}\right) \overline{\sqrt{R/2X}}$$

approximately, assuming R, the resistance per unit length of the line, to be small compared with X, the reactance per unit length.

The propagation constant $P = \alpha + j\beta$ where approximately $\alpha = \frac{R}{2}\sqrt{\frac{C}{L}}$ and $\beta = 2\pi/\lambda$.

The length l_1 of the transmission line is only half that of the dipole aerial, *i.e.*, $l_1 = l/2$.

In the case of Fig. 3, where $l = \lambda$, $l_1 = \lambda/2$, $\beta l_1 = \pi$ and

$$\tanh Pl_1 = \frac{\sinh \alpha l_1 \cos \beta l_1 + j \cosh \alpha l_1 \sin \beta l_1}{\cosh \alpha l_1 \cos \beta l_1 + j \sinh \alpha l_1 \sin \beta l_1}$$

reduces to $\sinh \alpha l_1/\cosh \alpha l$, which for small values of αl_1 is approximately equal to αl_1. Hence in this case we can put

$$Z_1 = \frac{Z_0}{\tanh Pl_1} = \sqrt{\frac{L}{C}} \times \left(1 + \frac{R^2}{4X^2}\right) \times \frac{2}{Rl_1}\sqrt{\frac{L}{C}}$$

$$= \frac{L}{C} \cdot \frac{2}{Rl_1} + \frac{Rl_1}{2} \cdot \frac{1}{l_1^2\omega^2 CL}$$

in which $l_1^2\omega^2 CL = \pi^2$. We have omitted the small phase angle $R/2X$ which indicates that the assumed condition, viz., that $l_1 = \lambda/2$, does not coincide exactly with the anti-resonant condition.

The question now arises as to the value to be given to Rl_1. This must obviously be such that the power dissipated in the equivalent line is the same as that radiated by the aerial. We saw above that, assuming the r.m.s. value of the current at its maximum point to be 1 ampere, the radiated power is 200 watts and, since the mean value of I^2 along the aerial is 0.5, the total resistance must be 400 ohms to give the same dissipation. Putting $Rl_1 = 400$ we have

$$Z_1 = \frac{1}{200} \cdot \frac{L}{C} + \frac{200}{\pi^2}$$

of which the second term is negligibly small. Substituting the values calculated above for L/C we have

d/l	$= 4 \times 10^{-3}$	4×10^{-4}	4×10^{-5}
l/d	$= 250$	2,500	25,000
$\sqrt{(L/C)}$	$= 662.4$	939	1,212
Z_1	$= 2,200$	4,400	7,350

These are the values of the radiation resistance for the case shown in Fig. 3.

We have thus arrived at the following results :

$f/f_o =$	0.5	1.0	1.5	2.0
Radiation Resistance =	13.5	73.2	374	2,200 to 7,350

These values agree fairly closely with those given by Salinger in the paper referred to in the July Editorial where the same three values of d/l are assumed.

The Reactive Component

At the exact resonant and anti-resonant frequencies the input impedance Z_1 is, of course, purely resistive. At frequencies well removed from these frequencies, as for example in Figs. 1 and 2, the approximate reactive component of the input impedance can be readily calculated by assuming the losses, and therefore α, to be negligible. Since we then have $\cosh \alpha l_1 = 1$ and $\sinh \alpha l_1 = 0$, $\tanh Pl_1 = j \tan \beta l_1$ and we can put

$$Z_1 = -jZ_0/\tan \beta l_1 = -j\frac{\sqrt{(L/C)}}{\tan \beta l_1}$$

In Fig. 1, $\lambda = 4l = 8l_1$, $\beta l_1 = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{8} = \pi/4$, and $\tan \beta l_1 = 1$, hence $Z_1 = -j\sqrt{(L/C)}$ and is capacitive. Similarly in Fig. 2, $l = 3\lambda/4$, $l_1 = 3\lambda/8$, $\beta l_1 = 3\pi/4$ and $\tan \beta l_1 = -1$, hence $Z_1 = j\sqrt{(L/C)}$ and is inductive. We saw above that for $l/d = 250$, 2,500, and 25,000 the values of $\sqrt{(L/C)}$ were 662.4, 939 and 1,212 ohms, but one must not be misled by these figures into thinking that the calculation gives highly accurate results. They are based on several very rough approximations including the calculation of L and C on the assumption that the electric field follows circular arcs between conical surfaces and is unaffected by the mistuning, but the difficulties are enormously increased by any attempt at greater accuracy.

G. W. O. H.

TIME-BASE CONVERTER AND FREQUENCY DIVIDER*

By Hilary Moss, Ph.D., B.Sc., A.M.I.E.E., A.M.Brit.I.R.E.

(*A. C. Cossor, Ltd.*)

SUMMARY.—A circuit is described which converts any arbitrary repetitive wave form into its own time base. The time base is essentially of the " driven " type and employs no meta-stable oscillators or trigger devices. This feature ensures a stability of a very high order. The circuit is fundamentally a frequency divider and may find its greatest use as such, rather than as a time base.

General

SOME time ago an article was published in *Wireless Engineer* by Nagy and Goddard[1] describing what they termed as a " Signal Converter." In essence this is a deflection valve employing a dual target having two portions of different secondary emission ratios. By this device the target is made to charge either negatively or positively according to the position of impact of the incident beam. These positive and negative excursions provide the time-base voltages. The arbitrary input signal is applied to the deflector plates of the valve so that the position of the beam on the target is rigidly locked to the signal under investigation. By this technique it is clear that perfect locking of the time-base voltage to the signal is ensured. When used in this simple way it is also apparent that only one cycle of the input wave can be examined (or, more accurately, one cycle less the flyback time), but Nagy and Goddard describe in the same article an elaboration whereby several such cycles can be displayed before the flyback operates.

In the author's opinion the main interest in the " Signal Converter " lies in the rigid locking between the signal and its time base. This mode of operation must be clearly distinguished from more conventional circuits which are often merely free-running oscillators constrained to work at a definite rate by synchronising pulses. Although the latter may be quite sufficiently stable for all normal visual work, they leave something to be desired for the most critical applications where long period stability is of real importance. On the other hand, the author feels that the introduction of a new and specialised type of valve is a retrograde step to achieve any object unless it is clearly impossible to reach the same ends by other methods. It is shown in the following article that a very similar result can be achieved by conventional techniques.

* MS. accepted by the Editor, May 1945.

Single-Cycle Time-Base Converter

The first fairly obvious step is to use the circuit shown diagrammatically in Fig. 1. Here the condenser C_1 is charged up from a constant voltage source through the resistor R_1. This provides the forward sweep

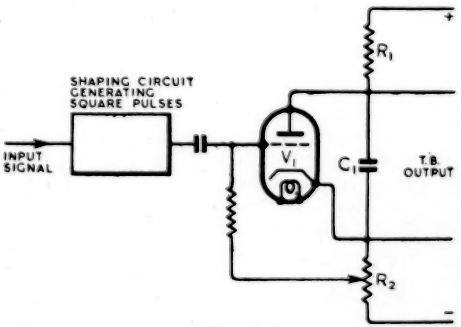

Fig. 1.

in the conventional manner, and, if linearity is desired, R_1 would be replaced by the usual constant current devices. A low impedance valve V_1 is connected across the time-base condenser C_1, and is normally biased beyond cut-off by the voltage drop across R_2. If we employ only the first part of the charging cycle, or if a constant current device is used, it is apparent that this voltage drop is sensibly

constant. By means of an auxiliary circuit, indicated diagrammatically in Fig. 1, a substantially square positive pulse is produced from the input signal, and this is applied to the grid of V_1. This pulse is

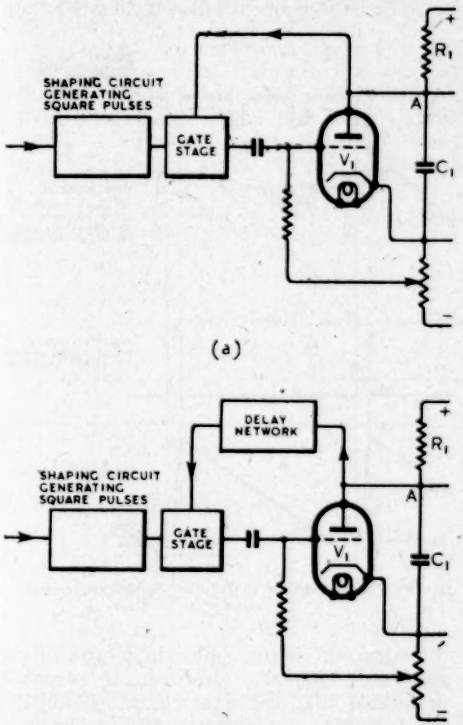

Fig. 2.

produced by conventional squaring circuits (not, of course, from triggered multi-vibrators, etc., since our specification requires the whole circuit to be quite free from meta-stable components). It should be sufficiently long to enable the valve V_1 to nearly discharge C_1, but sufficiently short to give a good flyback ratio. It is known from experiment that these requirements are not incompatible at audio frequencies, and calculation shows that they are also not incompatible at high frequencies, since then the condenser C_1 is smaller and contains less charge.

Here, then, is a simple driven time base, giving perfect locking, and using only standard components. It is a source of some surprise to the author that it has received so little attention, since for some work (e.g., waveform examination on wide-range beat-frequency oscillators) it would appear to be ideal. For such use it would be advisable to include a simple phase-shifting network in the input side, so as to permit the triggering pulse, and hence the flyback, to occur at any desired part of the single cycle under examination.

The only reference so far traced to such driven time bases occurs in von Ardenne's book, "Cathode Ray Tubes," p. 269. The method there described is identical with the foregoing, and is limited to examination of single cycles.

Multi-Cycle Time-Base Converter

It is apparent that for many purposes it is necessary to be able to examine several cycles before the flyback occurs. If we are to retain the general principles discussed, this necessitates the development of a circuit which will pass on only $1/n$ of the pulses generated by squaring the input signal, where $n = 2, 3, 4$, etc., depending on the number of complete cycles it is desired to view.

Such frequency division might be performed by conventional techniques, such as by the use of synchronised multi-vibrators, but only at the expense of introducing oscillatory elements into the network, and thus defeating the whole object of the work. The solution adopted is believed to be sufficiently novel to be of interest, and its synthesis is rather fascinating because it shows so clearly how any time base is fundamentally a frequency divider.

The basic method is illustrated by Figs. 2(*a*) and 2(*b*). Fig. 2(*a*) differs from Fig. 1 only in the addition of a "gate" valve after the pulse shaping stage. For the moment we need not enquire closely into its operation, beyond supposing that it is some form of valve with its grid in connection with the point A of the time-base charging network, and so arranged as to be cut off until the point A has charged up some way towards the positive rail voltage. Starting, then, from the instant when C_1 is discharged, the potential of A rises exponentially, and we may suppose, if R_1 and C_1 are appropriately chosen, that this rise is sufficiently slow for several pulses to be trapped by the gate valve before the rising potential of A makes it conducting. Idealising the operations for the moment by supposing that the gate opens suddenly, it is clear that the next

pulse will get through and make the discharge valve V_1 conduct so that the potential of point A will very rapidly fall. With the arrangement shown in Fig. 2(*a*) this fall would immediately close the gate valve before the pulse had completed its work, and the point A would reach a stable potential. This is avoided by the addition of a delay network connected between the point A and the gate, as shown in Fig. 2(*b*). The latter is thus not cut off until some time after the point A has fallen almost to zero potential, and after the discharging pulse has completed its work. This is the basic principle of the time-base converter when modified to display several cycles of the input wave. We now proceed to consider some of its features in more detail.

The "Gate" Stage

The most obvious form of gate is merely a multigrid valve, but the author was unable to find among the commoner preferred types, any valve in which two or more grids had a high slope. For this reason it was decided to employ a separate valve as a gate stage. The desirability for using a gate valve with high slope should be obvious, since it is very necessary that the relatively slowly changing potential on C_1 should open the gate as suddenly as possible, so that there is a minimum risk of partial opening on an earlier pulse.

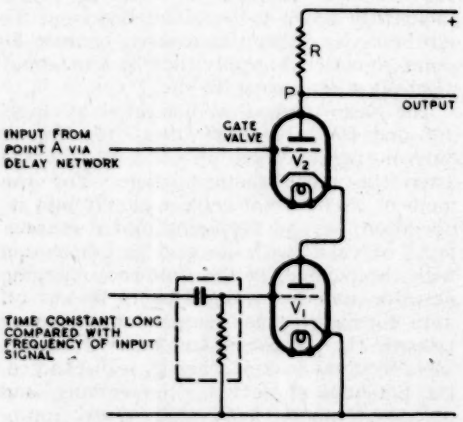

Fig. 3.

At first sight it might seem that a biased-back valve following the pulse-shaping stage is all that is necessary, but this arrangement would be far from ideal, since it would transmit a pulse when the point A reached a suitable potential, regardless of conditions in the main pulsing circuit. It is true that by suitable choice of time constants it might be possible to discriminate between this pulse and the train of pulses generated from

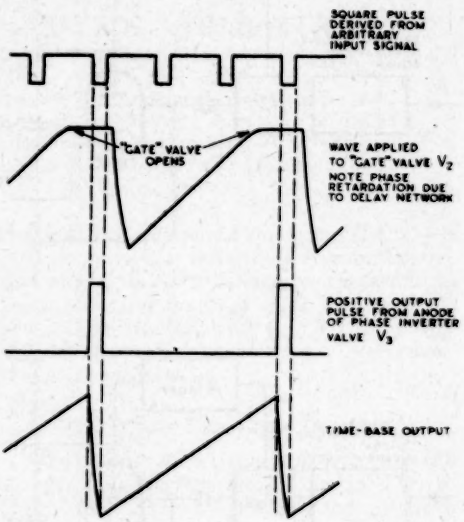
SQUARE PULSE DERIVED FROM ARBITRARY INPUT SIGNAL
"GATE" VALVE OPENS
WAVE APPLIED TO "GATE" VALVE V2
NOTE PHASE RETARDATION DUE TO DELAY NETWORK
POSITIVE OUTPUT PULSE FROM ANODE OF PHASE INVERTER VALVE V3
TIME-BASE OUTPUT

Fig. 4. *Idealised waveforms in the time-base converter.*

the squaring circuit, since their rates of rise are very different. However, it is clearly preferable that the gate circuit should not itself initiate a pulse of any sort when it opens, but that it should be merely ready to transmit the next pulse from the shaping stage.

This requirement may be very satisfactorily met by means of the circuit network shown diagrammatically in Fig. 3. Here the valve V_2 is part of the anode load for the valve V_1, the latter being operated under Class C self-biasing conditions. R is the remainder of the anode load. If the valve V_2 is cut-off, its effective internal resistance is almost infinite, so that the point P is at full rail potential regardless of what is happening to the valve V_1. Hence in these conditions no pulse on the grid of V_1 can be transmitted. On the other hand, if the valve V_2 is made conducting no pulse is transmitted, since unless V_1 is simultaneously conducting no current can flow down R.

These are the ideal conditions which the gate of the time-base converter must satisfy.

Normally when the point A of Fig. 2 (*a*) or (*b*), is insufficiently positive, then the valve V_2 is arranged to be cut-off, so that pulses arriving on the grid of V_1 are not transmitted. The grid of V_2 is connected to point A via a delay network, and as A rises in potential the grid of V_2 is made progressively more positive until the valve becomes conducting. This valve does not transmit any pulse, as discussed above, but now waits until the next pulse arrives on V_1, and this is fully transmitted. Note that as soon as the valve V_1 becomes conducting the voltage drop across it falls, and this drives the grid of V_2 more positive so ensuring the most favourable conditions for pulse transmission.

converter is shown in Fig. 5. The photographs given in Fig. 6 were obtained with the values of components specified on Fig. 5, but it is not suggested that the values have been chosen with especial care to ensure optimum performance. The values of the components given relate to operation at 50 c/s and, owing to pressure of other work, it was not found possible to investigate conditions at higher frequencies.

It will be noted that the simple charging resistor has been replaced by a linearising network of the cathode-follower type.[2]

The input circuit operates under Class C conditions and thus loads the driving network — a feature which may well be

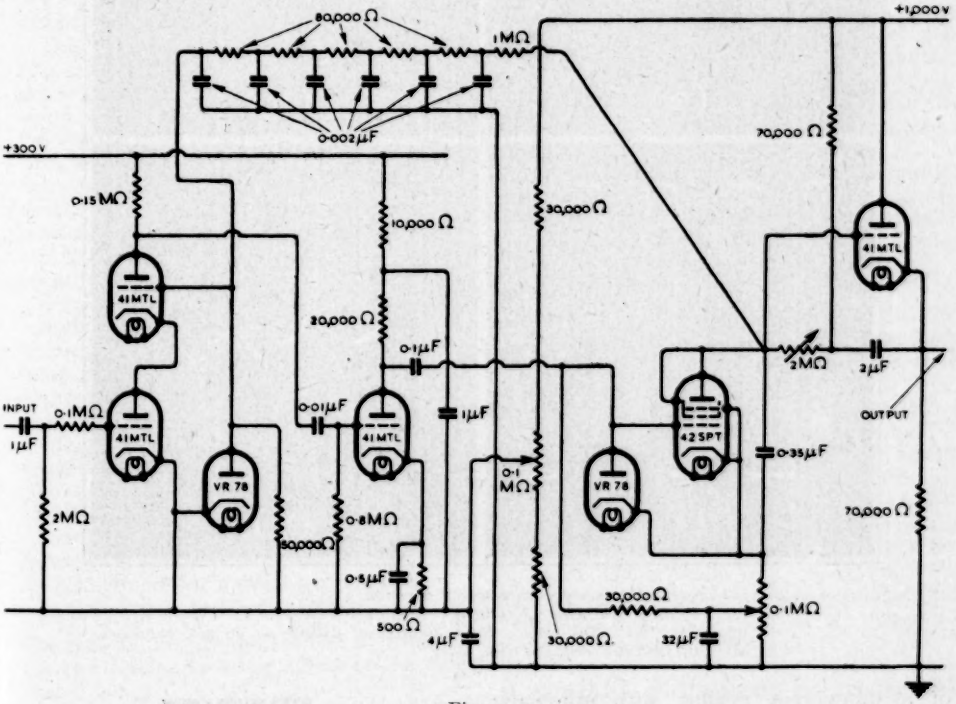

Fig. 5.

Fig. 4 shows the phase relationships of the various waveforms relating to the time-base converter. This should be self-explanatory in view of the foregoing discussions.

Practical Form of Circuit

To assist further experimental work, a complete circuit diagram of a satisfactory

undesirable for many uses. This can be conveniently avoided by adding a cathode follower input stage (not shown).

Figs. 6 (*a*) to (*d*) show photographs of various waveforms displayed by the time-base converter. In all cases the exposure time was 20 secs., and the definition of the traces and especially of the flyback portions, testify to the stability obtainable.

Acknowledgments

The basic circuit of the converter was worked out in my private laboratory as part of a programme dealing with automatic computing engines. Some additional work on it was also done at A. C. Cossor Ltd., during investigations on stable focus patterns, and I am indebted to J. K. Tollyfield and D. C. Phipps for their help.

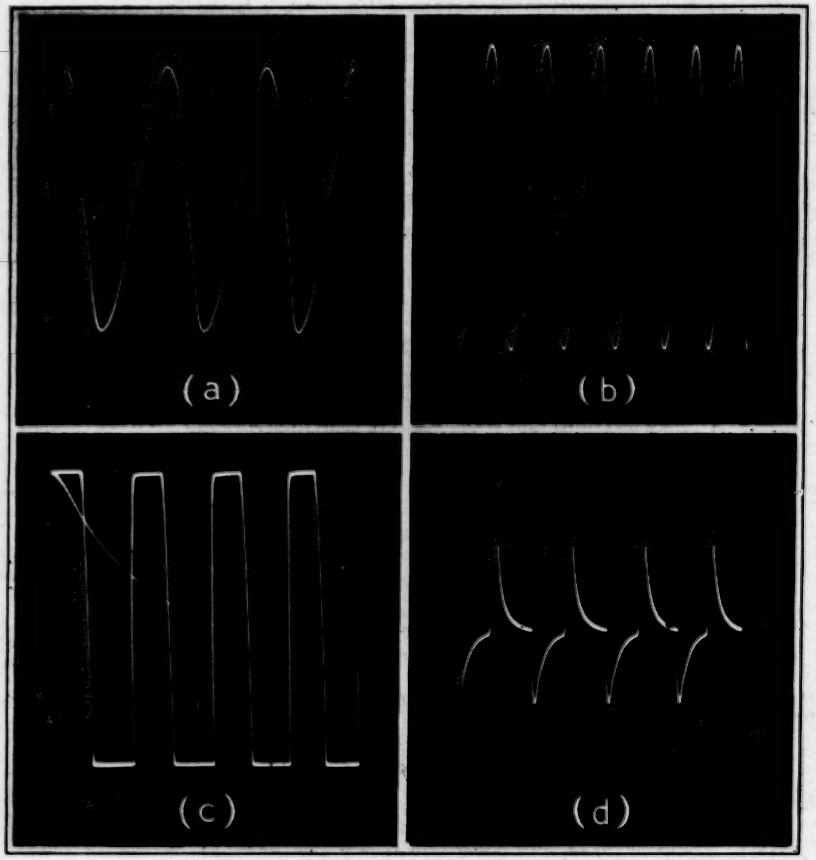

Fig. 6. (a) *Distorted sine wave* (*Frequency division* 3 : 1).
(b) *Distorted sine wave* (*Frequency division* 6 : 1).
(c) "*Chopped*" *sine wave. Note stability of flyback on* 20 *sec. exposure.*
(d) *Differentiated chopped sine wave.*

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MUTUAL INDUCTANCE*

Simplified Calculations for Concentric Solenoids

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1. Introduction

THE calculation of mutual inductance is usually a somewhat laborious process, and it is not readily apparent, from the formulæ used, how a change in one of the coil dimensions will affect the result, nor what one should do to obtain the best design of coil.

This paper is concerned with the case of two concentric solenoids, symmetrically disposed about their common centre-line and, by means of curves, it is possible to reduce the calculations to a simplicity comparable with that of determining self-inductance. At the same time the effect of variation of each parameter is at once evident, and it is possible to see, at a glance, what shape of coil should be adopted for a given set of conditions.

Some notes are appended on the design of coupling coils covering the cases of obtaining (i) maximum mutual inductance, (ii) maximum co-efficient of coupling (k), (iii) maximum step-up ratio of current into an untuned secondary circuit in which the reactance predominates over the resistance, and a further case is considered, viz., (iv) variometers, where one is usually interested in obtaining maximum variation of inductance.

With the aid of the curves now derived, a factor P is obtained for use in the following simple formula for mutual inductance :—

$$M = P \,.\, a \,.\, n_1 \,.\, n_2 \,\mu\text{H}$$

where n_1 and n_2 are the number of turns on the two coils, and a the radius of the inner one.

A summary of the general conclusions reached and the procedure for making calculations is given in Sections 2 and 3, following. The method to be used is thus immediately apparent without the necessity of searching through the main body of the paper ; this latter follows in Sections 4 onwards and gives the derivation of the various equations and curves.

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2. General Conclusions

(i) To obtain the maximum mutual inductance, maximum k, greatest step-up ratio of currents (where the secondary circuit is untuned and the secondary reactance $\geqslant 3$ times the secondary resistance), or greatest change of inductance in variometers, keep the ratio of coil diameters (c) as near unity as possible, and the lengths of inner and outer coils the same. In the case of mutual inductance only, a 5–10 per cent. improvement is obtained if one coil is made half the length of the other, assuming the longer to be fixed in length.

(ii) To obtain the highest value of mutual inductance, i.e., to obtain the highest value of P, regardless of other considerations, keep the length-to-diameter ratio small, around a value of 0.2 to 0.3 (compare with (iii)).

(iii) To obtain the highest value of k, greatest step-up ratio of currents, or greatest change of inductance in variometers, keep the length-to-diameter ratio not less than 0.7 (compare with (ii)).

(iv) To obtain the maximum variation of inductance in a variometer, make the inductances of the two coils equal ; however, a ratio between 0.8 and 1.2 is tolerable. With coils of equal length (see (i)) the inductances can be made equal if the number of turns on the coils are in the inverse ratio of their diameters.

(v) A higher value of step-up ratio of currents is obtained if the inner coil is on the secondary side, by a ratio of $c^{3/2}$ compared with the reverse arrangement.

3. Summary of Procedure for making Calculations

The curves which give values of P and k in terms of length-to-diameter ratios of the coils are applicable for the case of the outer coil being the shorter or the inner coil the shorter. In the first case use the ratios x/a and l/A while for the latter use l/a and x/A.

Worked examples are given on pages 377, 381, and 383.

(*a*) The value of mutual inductance is

obtained from equation (6), the value of P being obtained by the use of any of Figs. 2 to 8.

Figs. 2 and 3 are for the special case when $x/a = l/A$ or $l/a = x/A$.

Figs. 4 and 5 are for the general case of any combination of values of x/a and l/A—or l/a and x/A—but are given for only one value of c, viz., 1.2. To determine P for any other value of c, obtain the multiplying factor from Fig. 6.

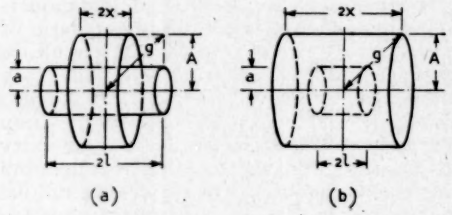


Fig. 1. *Types of coil discussed and symbols used.*
(a) *Outer coil shorter*, $g = \sqrt{l^2 + A^2}$;
(b) *Inner coil shorter*, $g = \sqrt{x^2 + A^2}$.
All dimensions are in cm.

Figs. 7 and 8 are for the special case when $x = l$, i.e., the coils are of equal length.

(*b*) The value of self-inductance of either coil is obtained from equation (10), the value of F being obtained from Fig. 10.

(*c*) The co-efficient of coupling (k) is obtained from equation (14) which is applicable to all shapes of coil. The values of P and F to be used in this are obtained as in (*a*) and (*b*) above.

For the special case of $x/a = l/A$—or $l/a = x/A$—the value of k can be obtained direct from Fig. 11.

For the special case of $x = l$, the value of k can be obtained direct from Fig. 12.

(*d*) For a coupled circuit, with untuned secondary and in which the secondary reactance is all comprised in the coupling coil and is $\geqslant 3$ times the secondary resistance, the ratio of secondary-to-primary current, or turns ratio for a given current ratio, can be obtained from equations (16) to (19).

Equations (16) and (18) are alternative forms for use when the outer coil is the secondary. Equations (17) and (19) are the corresponding forms when the inner coil is the secondary.

For the special case of $x = l$, the simpler equations (20) and (21) may be used; these correspond to the case of the outer and inner coil being the secondary, respectively.

(*e*) Where the secondary inductance, for the type of circuit as in (*d*), is divided between the external circuit and secondary coil—the ratio being expressed as q—equations (16) to (21) are modified by inserting the factor $(1 + q)$ in the denominator of the right-hand side.

For the special case of $x = l$, we then use equations (23) and (24).

(*f*) For a coupled circuit as in (*e*), in which the primary is tuned to a certain frequency, the equivalent primary inductance is given by equation (25). From this we can find what the actual primary coil inductance must be, having decided upon the desired primary current, and hence, the equivalent primary reactance.

k is obtained as in (*c*), hence n_1 is found as in (*b*). Since the turns ratio will have been determined as in (*d*) or (*e*), n_2 is obtainable. For the special case of $x = l$, equation (26) can be used.

(*g*) For a variometer we may start from one or other of several given requirements as discussed on pp. 382–3. From one or other of equations (28) to (33), or Fig. 15, the value of k will then be obtained.

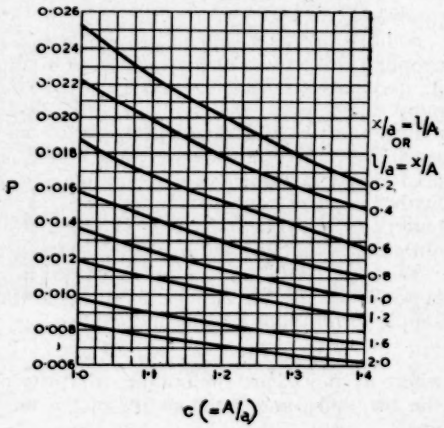


Fig. 2. *P versus c for special case of* $x/a = l/A$ *(outer coil shorter), or* $l/a = x/A$ *(inner coil shorter).*

From Fig. 12, c and x/a can then be settled to attain this value, and thence the self-inductance required for each coil can be determined from equation (29), (30) or (32). The number of turns on one coil is then obtained as in (*b*) and of the other by the use of equation (25).

4. Calculations of Mutual Inductance

This work is based upon the formulæ, for two concentric solenoids, given in the Bureau of Standards, Circular C74, p. 280, expressed by the following equations, the significance of the symbols being obtained from Figs. 1 (*a*) and 1 (*b*).

With the outer coil the shorter,

$$M = 0.01974\frac{a^2n_1n_2}{g}\left[1 + \frac{A^2a^2}{8g^4}\left(3 - 4\frac{x^2}{a^2}\right)\right]\mu\text{H} \quad .. \quad .. \quad (1)$$

and with the inner coil the shorter

$$M = 0.01974\frac{a^2n_1n_2}{g}\left[1 + \frac{A^2a^2}{8g^4}\left(3 - 4\frac{l^2}{a^2}\right)\right]\mu\text{H} \quad .. \quad .. \quad (2)$$

all dimensions being in cm.

Express the ratio of coil diameters as c, i.e., $c = \frac{A}{a}$. For equation (1),

$$g \doteq \sqrt{l^2 + A^2} = A\sqrt{1 + \frac{l^2}{A^2}}$$

$$= ac\sqrt{1 + \frac{l^2}{A^2}} = aZ \text{ say} \quad .. \quad (3)$$

Let X be the term in square brackets, i.e.,

$$X = 1 + \frac{A^2a^2}{8g^4}\left(3 - 4\frac{x^2}{a^2}\right)$$

$$= 1 + \frac{\left(3 - 4\frac{x^2}{a^2}\right)}{8c^2\left(1 + \frac{l^2}{A^2}\right)^2} \quad .. \quad .. \quad (4)$$

Hence $M = 0.01974 \cdot \frac{a^2 \cdot n_1n_2}{aZ} \cdot X$

or putting $P = 0.01974\, X/Z$ .. .. (5)

we obtain the simple equation for the mutual inductance of

$$M = P \cdot a \cdot n_1 \cdot n_2\, \mu\text{H} \quad .. \quad .. \quad (6)$$

It will be noticed that both X and Z, and hence P, are functions only of ratios of coil parameters and not on actual dimensions. We can, therefore, obtain families of curves expressing P in terms of $c(= A/a)$, x/a and l/A which will apply to any coil. In designing a coil, therefore, we commence by assigning values to these ratios and hence obtain P from the curves. Substitution in equation (6) then yields the value of mutual inductance directly. Equations (1) and (2) differ only in the interchange of x and l, so that for coils in which the inner coil is the shorter, we can still use our curves, and equation (6), if we use the ratios l/a and x/A in place of x/a and l/A.

Utilising equations (3), (4) and (5), sets of curves have been prepared giving the value

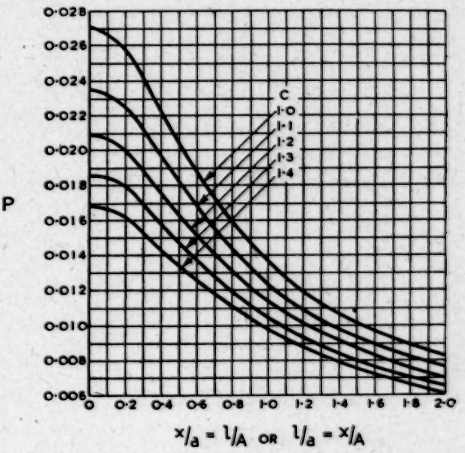


Fig. 3. *P versus length/diameter ratio for special case of $x/a = l/A$ (outer coil shorter), or $l/a = x/A$ (inner coil shorter).*

of P for different ratios of coil parameters. These are arranged as follows :—

Fig. 2 shows P versus c for different values of x/a and l/A in the special case when these ratios are made equal, for the outer coil the shorter, or of l/a and x/A when the inner coil is the shorter.

Fig. 3 shows P versus x/a and l/A for different values of c in the special case when these ratios are equal, for the outer coil the shorter, or l/a and x/A when the inner coil is the shorter.

Fig. 4 shows P versus l/A for different values of x/a (or versus x/A for different values of l/a, inner coil the shorter), whilst Fig. 5 shows the data presented against variation of x/a (or l/a) for several values of l/A (or x/A), the third variable, c, being fixed in value. The value chosen for c is 1.2, this being an average value obtainable in practice. Figs. 4 and 5 enable the value of P to be obtained for any values of x/a and l/A, or l/a and x/A for the one value of c of 1.2. In order to be able to extend their use to other values of c, Fig. 6 has been prepared. This has been derived from Fig. 2, and gives a multiplying factor which must be used to convert the value of P obtained from Figs. 4 and 5 if c has a value other than 1.2. Several

curves are necessary for this factor since its value depends upon x/a and l/A ; in using it one takes the curve nearest to the value adopted for these. Thus, the use of Figs. 4, 5 and 6 enables P to be obtained for any combination of the three variables.

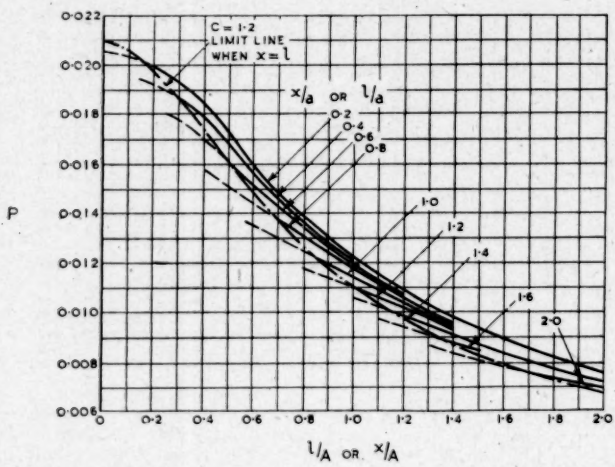


Fig. 4 (Left). *P versus l/A (outer coil shorter), or x/A (inner coil shorter). Given for one value of c = 1.2. For other values of c, obtain factor from Fig. 6 with which to multiply P obtained \from this figure to determine the value of P for the given value of c.*

Fig. 5. (Below). *P versus x/a (outer coil shorter), or l/a (inner coil shorter). Given for one value of c = 1.2 For other values of c, obtain factor from Fig. 6 with which to multiply P obtained from this figure to determine the value of P for the given value of c.*

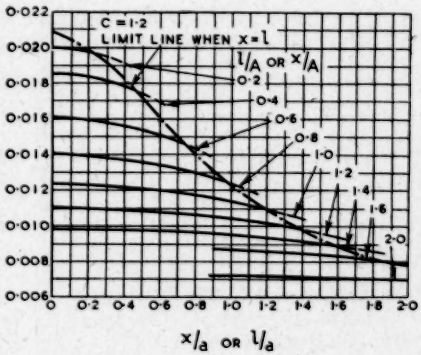
For the special case of the two coils having equal lengths, i.e., $x = l$, the number of curves can be reduced since now we have only two variables, viz., c and x/a $(= l/a)$. Equation (4), for X, now becomes

$$X = 1 + \frac{c^2(3 - 4x^2/a^2)}{8(c^2 + x^2/a^2)^2} \quad \ldots \quad \ldots \quad (7)$$

and $$Z = \sqrt{c^2 + \frac{x^2}{a^2}} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

From these equations Figs. 7 and 8 have been derived showing, respectively, P versus c for different values of $x/a(= l/a)$, and P versus $x/a(= l/a)$ for different values of c. Values of P for all shapes of coil can thus be obtained from these curves for this special case of $x = l$. We shall see later that there are reasons for adhering to this whenever possible.

Some general conclusions can now be drawn from a study of Figs. 2 to 8 regarding the variations of P with coil parameters. Firstly, c makes a considerable difference to the value of P and should be reduced as much as possible ; we can see, therefore, that it is easier to obtain a desired value of mutual inductance with large diameter coils than with small, for a given clearance between inner and outer coils, since in the larger coil this clearance represents a smaller fraction of the diameter, so that c is smaller. Secondly, P is a maximum when x/a and l/A are reduced to zero, but the rate of increase is small below $x/a = 0.2$. It is of interest to note that the maximum value of P theoretically possible is 0.0271 and is obtained for zero



length coils and a diameter ratio of 1. If we consider a practical case of a well-designed coil, this might have $c = 1.1$ and $x/a = 0.2$ $(x = l)$, whence $P = 0.0221$ from Fig. 8 ; this is 81 per cent. of the theoretical maximum, and could only be obtained with large diameter coils.

It is not at once apparent from the formulæ or figures so far given, whether there is any optimum ratio between the lengths of the two coils. Let s be the ratio between the lengths of inner and outer coils, i.e., $s = x/l$, then from the data of Figs. 4 and 5—i.e., for a fixed value of c of 1.2—we obtain the curves of Fig. 9. We

thus see that if either coil is fixed in length, P increases rapidly as the other coil is made shorter until the two coils are equal in length, but after that the increase is slight and a maximum is approached when the coil being varied is half the length of the fixed one. The increase beyond the value when the coils are equal in length is, however, small, and amounts only to some 5 to 12 per cent. depending on the length/diameter ratio. For practical purposes, therefore, we shall lose little if we make the two coils of equal length, this being usually the simplest form of construction.

It should be remembered that the above conclusions on coil parameters apply only to a consideration of obtaining the maximum value of the factor P, hence of mutual inductance. We shall see in the next section that quite different conclusions are arrived at when one is concerned with maximum coefficient of coupling, etc.

Example.—A small coil is required to give a mutual inductance of 30 μH. Former sizes available are $2\frac{5}{8}$in. and $3\frac{1}{8}$in. diameter, giving mean diameters of winding of 6.75 and 8.0 cm. respectively; c is thus 1.2. The outer coil is to be the shorter, the winding length being about half that on the inner coil. To make P large we choose x/a as 0.3 and l/A as 0.5, hence the winding lengths are

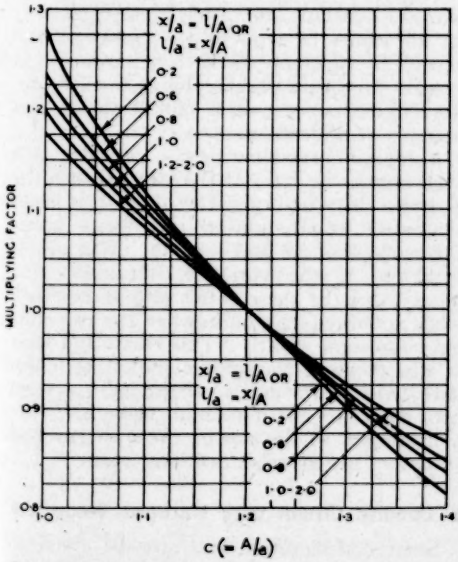


Fig. 6. *Multiplying factor plotted against c. Use this factor with Figs. 4 and 5, to obtain the value of P for values of c other than 1.2.*

2.1 and 4.0 cm. From Fig. 5, for these values, $P = 0.0170$. Using equation (6) we have $30 = 0.0170 \times 3.375 \times n_i n_o \therefore n_i n_o = 524$. As n_i will be approximately double n_o we fix on n_i as 32 turns and n_o as 16 turns. This

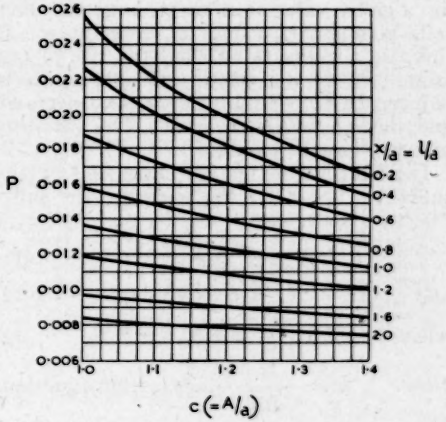


Fig. 7. *P versus c for special case of x = (both coils same length).*

makes $n_i n_o = 512$, so the final calculated value of M will be 29.4 μH. The measured value of a coil wound to this specification was 29.7 μH, the two values thus being in good agreement.

5. Calculation of Co-efficient of Coupling

Before we can obtain information on the co-efficient of coupling (k) we must express the self-inductance of the windings in suitable form. For this, Nagaoka's formula is used and the "shape-factor" is exhibited by means of a curve. Such a curve appears in several handbooks, but is here repeated for completeness, so that one may have available all the necessary data to design a given coupling coil or variometer.

If a and b represent the radius and length of a coil, n the number of turns and K, Nagaoka's factor, the self-inductance, L, is given by

$$L = \frac{0.0395\ a^2 \cdot n^2 \cdot K}{b}\ \mu\text{H} \quad \ldots \quad \ldots \quad (9)$$

which can be re-written as

$$L = F \cdot D \cdot n^2\ \mu\text{H} \quad \ldots \quad \ldots \quad (10)$$

where D is the diameter ($= 2a$), and

$$F = \frac{0.0395}{2} \cdot \frac{a}{b} \cdot K$$

F may be called the "shape-factor" and depends only on the ratio of length-to-diameter. It is plotted in Fig. 10 on a logarithmic scale to cover a wide range of values of b/D. The value of F rises rapidly as b/D is reduced below about 0.5, so that, for a given value of n, short, large diameter coils give higher values of inductance. If this rise is more rapid than the rise of our factor P, as the length/diameter ratio is reduced, it is possible that k may decrease and this we find is the case. The variation of k will now be examined.

Denoting values for the inner coil by the suffix "$_i$" and for the outer by the suffix "$_o$" we shall have :—

$$L_i = F_i \cdot 2a \cdot n_i^2 \quad .. \quad .. \quad (11)$$

and $$L_o = F_o \cdot 2ac \cdot n_o^2 \quad .. \quad .. \quad (12)$$

whence $$\sqrt{L_i L_o} = 2a\, n_i n_o \sqrt{c\, F_o F_i} \quad (13)$$

Now $k = \dfrac{M}{\sqrt{L_i L_o}}$, hence, from equations (6) and (13)

$$k = \frac{P \cdot a \cdot n_i \cdot n_o}{2a \cdot n_i n_o \sqrt{c\, F_o F_i}}$$

i.e.,

$$k = \frac{P}{2\sqrt{c\, F_o F_i}} \quad .. \quad .. \quad (14)$$

This formula is true for all coil parameters and it is only necessary to obtain P from the curves already given and F_o and F_i from Fig. 10, in order to obtain the value of k. Note that k is a function only of the relative dimensions of the coil and does not depend on the number of turns or the absolute values of the dimensions.

Corresponding to the two specific ratios we have already taken of $x/a = l/A$ (or $l/a = x/A$) and $x = l$, the values of k obtained, from equation (14), are plotted in Figs. 11 and 12. The latter is useful, particularly for variometer design, as we shall see in Section 7.

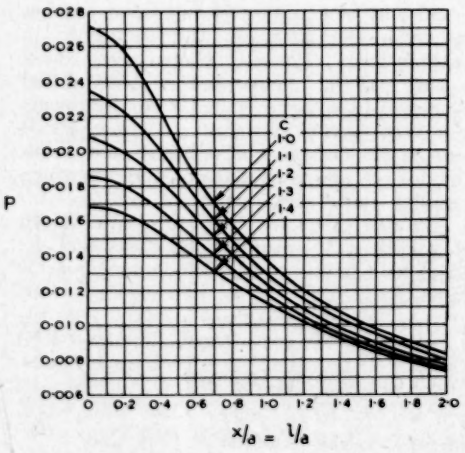


Fig. 8. *P versus x/a for special case of $x = l$ (both coils same length).*

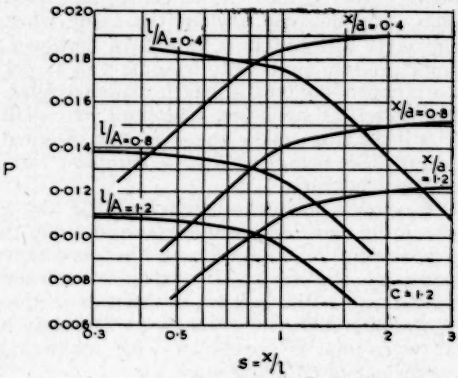


Fig. 9. *Illustrating variation of P with change in ratio of coil lengths.*

These curves show the rapid rise of k with increase of length/diameter ratio, k becoming sensibly constant for ratios greater than 1, for all values of c up to 1.4; the increase beyond a ratio of about 0.7, however, is small. To obtain a high value of k, therefore, the length/diameter ratio should not be less than 0.7 or thereabouts.

A typical curve showing the variation of k with change in ratio of the two coil lengths is given in Fig. 13. The data has been evaluated from equation (14) for a given value of x/a of 0.8 and $c = 1.2$. It is representative of the variation obtainable for other values of these ratios and shows that k has a marked maximum when the two coils have the same length. This result and that in the previous paragraph should be compared with the conclusions reached on page 376, regarding the maximum value of P.

Examples of the use of these curves and equations are given in Sections 6 and 7.

6. Coupled Circuit with Untuned Secondary

Some consideration will now be given to the case of a coupled circuit in which the secondary circuit is untuned and the second-

ary inductive reactance is at least three times as large as the resistance. It is desired to obtain as great a step-up ratio of currents between secondary and primary circuits as possible; such conditions arise, for example, in heating metals by high-frequency induction either between the "work" coil and the load or in a high-frequency transformer interposed between the former and the "tank" circuit of a high-frequency generator.

Fig. 10 (Right). *"Shape-factor," F, plotted against b/D, length/diameter ratio, for self-inductance calculations.*

Fig. 11 (Below). *k versus length/diameter ratio for special case of x/a = l/A (outer coil shorter) or l/a = x/A (inner coil shorter).*

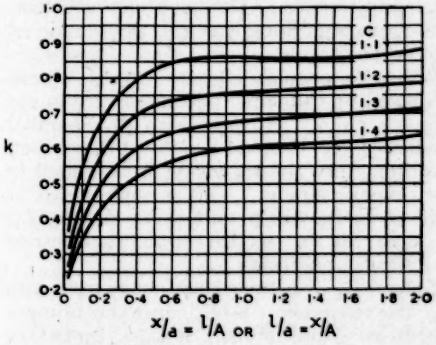


Fig. 14 (*a*) represents the simplest case when all the inductance on the secondary side is contained in the coupling coil itself or, at least, this inductance is large compared with any other external to the coil. In the secondary circuit

$$\omega MI_1 - I_2\sqrt{\omega^2L_2^2 + R_2^2} = 0.$$

Now if $R_2 \leqslant \frac{1}{3}\omega L_2$ then the factor under the root sign will become $\omega^2L_2^2$ with an error less than 10 per cent. Hence $\omega MI_1 = \omega L_2 I_2$, within 5 per cent. or less, or

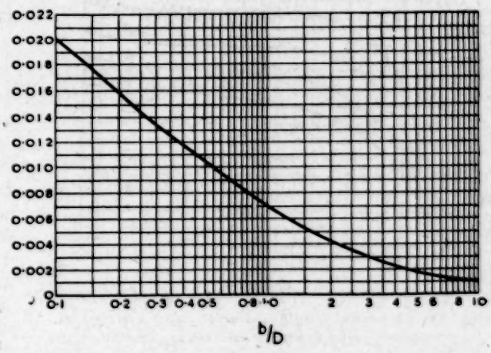
$$\frac{I_2}{I_1} = \frac{M}{L_2} \quad .. \quad .. \quad .. \quad .. \quad (15)$$

Thus to make $\frac{I_2}{I_1}$ as large as possible we must make $\frac{M}{L_2}$ large.

Let the secondary be the outer coil, then from equations (6) and (12) we have

$$\frac{I_o}{I_i} = \frac{M}{L_o} = \frac{P \,.\, a \,.\, n_i n_o}{F_o \,.\, 2ac \,.\, n_o^2} = \frac{P}{2cF_o} \cdot \frac{n_i}{n_o} \quad (16)$$

whilst if the secondary is the inner coil,



using equations (6) and (11)

$$\frac{I_i}{I_o} = \frac{M}{L_i} = \frac{P \,.\, a \,.\, n_i n_o}{F_i \,.\, 2a \,.\, n_i^2} = \frac{P}{2F_i} \cdot \frac{n_o}{n_i} \quad (17)$$

These may be expressed in terms of k, by substituting for P from equation (14)

Whence $$\frac{I_o}{I_i} = \frac{M}{L_o} = k \,.\, \frac{n_i}{n_o} \cdot \sqrt{\frac{F_i}{cF_o}} \quad .. \quad (18)$$

and $$\frac{I_i}{I_o} = \frac{M}{L_i} = k \,.\, \frac{n_o}{n_i} \cdot \sqrt{\frac{cF_o}{F_i}} \quad .. \quad (19)$$

Thus, by obtaining P and F_o or F_i, or k, F_o and F_i from our curves we can readily find the turns ratio required to obtain a given current ratio, or the current ratio obtainable with a given turns ratio.

Since we nearly always want I_2/I_1 to be as large as possible we shall therefore choose a coil in which inner and outer windings are of the same length, to make k a maximum. For this particular case, we have evaluated the ratio F_o/F_i and find that, for any value of c up to 1.4, the ratio F_o/F_i is sensibly constant for all values of x/a between 0.4 and 2.0 and has a value which is approximately equal to $1.02\sqrt{c}$ with an error not exceeding 3 per cent., whilst if we take the value as $\sqrt{c}$ the error does not exceed 5 per cent. Substitution in equations (18) and (19) yields therefore

$$\frac{I_o}{I_i} = \frac{M}{L_o} = \frac{k}{c^{\frac{1}{2}}} \cdot \frac{n_i}{n_o} \quad .. \quad .. \quad (20)$$

and $$\frac{I_i}{I_o} = \frac{M}{L_i} = kc^{\frac{3}{2}} \cdot \frac{n_o}{n_i} \quad .. \quad .. \quad (21)$$

with an error of about 2 per cent. on the basis of the simpler figure for F_o/F_i only.

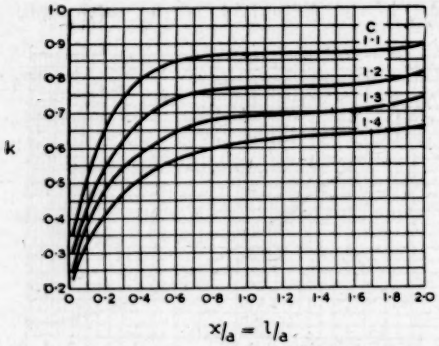


Fig. 12. *k versus length/diameter ratio for special case of $x = l$ (both coils same length).*

Under these special conditions, we shall only need to use Fig. 12 to obtain k to solve these equations. With a given coil, therefore, we see that for the same ratio of currents we require a smaller turns ratio if the inner coil is the secondary by a factor of $c^{3/2}$, or, alternatively, for the same turns ratio the current ratio is increased by a factor of $c^{3/2}$, compared with the reverse arrangement.

When the external inductance is not small, the preceding equations require modification. The revised calculations are easiest to make if we consider the external inductance as bearing some ratio (q) to the coupling coil secondary inductance (L_2). Thus in Fig. 14 (*b*) the external inductance is denoted by L_x, and we take $L_x = qL_2$ (usually $q \ll 1$).

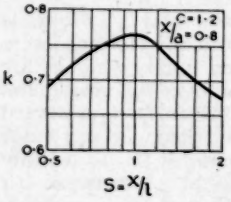
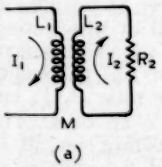
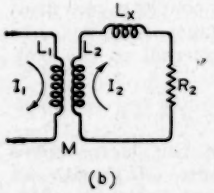


Fig. 13. *Illustrating variation of k with change in ratio of coil lengths.*





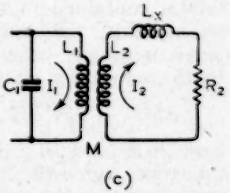


Fig. 14. *Coupled circuits, with untuned secondary.* (a) *with no external inductance.* (b) *with external inductance.* (c) *with external inductance and tuned primary.*

Then equation (15) is modified to

$$\frac{I_2}{I_1} = \frac{M}{L_2 + L_x} = \frac{M}{(1+q)L_2} \quad .. \quad (22)$$

Equations (16) to (21) are thus all modified by the inclusion of the factor $(1 + q)$ in the denominator of the right-hand side. This shows that the step-up ratio is smaller than for the case with no external inductance by this factor or if we wish to obtain a definite ratio of currents then n_1/n_2 will have to be increased in the ratio $(1 + q) : 1$. As we shall need the modified forms of equations (20) and (21) later, these are given here as

$$\frac{I_o}{I_i} = \frac{M}{(1+q)L_o} = \frac{k}{(1+q)c^{\frac{3}{2}}} \cdot \frac{n_i}{n_o} \quad .. \quad (23)$$

$$\frac{I_i}{I_o} = \frac{M}{(1+q)L_i} = \frac{k \cdot c^{\frac{3}{2}}}{(1+q)} \cdot \frac{n_o}{n_i} \quad .. \quad (24)$$

In making calculations on a coil, L_x will be known but q will not be, since L_2 is unknown until n_2 has been determined. We must, therefore, make an initial assumption of an expected value of q, work out the value of n_1/n_2 from equations (23) or (24) and obtain L_1 and L_2 having decided upon n_1 or n_2. If L_2 and L_x are not in the assumed ratio q, we can then assume a much nearer value and re-work. The process is so simple with these equations that the time involved is very small.

When the primary circuit is tuned, n_1 will be settled by the inductance necessary in the primary circuit to tune with the parallel condenser, the value of which will have been determined by the kVA/kW ratio desired in the primary circuit. This is represented in Fig. 14 (*c*) in which values for I_1, I_2, L_x, C_1, can all be settled from the desired operating conditions.

Since $(L_2 + L_x)$ is large compared with R_2, the reactance coupled into the primary circuit is $-(\omega M)^2/\omega(L_2 + L_x)$; hence the equivalent primary reactance is $\omega L_1 - (\omega M)^2/\omega(L_2 + L_x)$, or the equivalent primary inductance is $L_1 - M^2/(L_2 + L_x) = L_1 - M^2/(1 + q)\,L_2$. As $k^2 = M^2/L_1L_2$, the equivalent primary inductance L_p is given by

$$L_p = L_1\left[1 - \frac{k^2}{(1+q)}\right] \quad .. \quad .. \quad (25)$$

and it is this inductance which tunes with C_1 to the desired operating frequency. Since C_1 has been settled to give the desired current I_1, we then know the value of L_2, whence L_1 is found from equation (25). Equation (25) reduces to the usual formula of $L_1(1 - k^2)$, for a circuit with no external inductance, i.e., when $q = 0$.

In designing a coil, we now settle on a suitable length/diameter ratio and ratio of coil diameters and so obtain the expected value of k, e.g., from Fig. 12. Substitution in equation (25) thus gives us L_1 and hence n_1 is found by the use of equation (10) and Fig. 10. From this and the ratio of n_1/n_2 obtained from equations (23) or (24), n_2, and hence L_2, are immediately obtained. A check can be made by finding M, after obtaining P from the appropriate curves, and thence checking on the value of k from $k = M/\sqrt{L_1 L_2}$.

If the coils are of the same length, we need not work out L_2 at the end of the calculations as above, but can do so early on and thus get a quick check on our assumed value of q. We found that for the range of c up to 1.4, the shape factors of the outer and inner coils were related by $F_o/F_i \doteqdot \sqrt{c}$ (see page 379).

$$\therefore \quad L_i = \frac{F_o}{\sqrt{c}} \cdot 2a\, n_i^2 \quad \text{and} \quad L_o = F_o \cdot 2ac \cdot n_o^2$$

whence

$$\frac{L_i}{L_o} = \frac{1}{c^{3/2}} \left(\frac{n_i}{n_o}\right)^2 \quad \text{and} \quad \frac{L_o}{L_i} = c^{3/2} \left(\frac{n_o}{n_i}\right)^2 \qquad \ldots \quad \ldots \quad (26)$$

Having determined L_1 as above, we can see immediately what L_2 will be since we have already obtained n_1/n_2 from the desired ratio of currents. The relation between L_1 and L_2 is thus fixed by the turns ratio, i.e., is settled by the current ratio we need.

Example.—H.F. transformer with tuned primary and untuned secondary. Primary current to be 24 A., secondary 83 A., external inductance 1.5 μH, frequency 200 kc/s, the primary reactance being 90 ohms.

We decide upon a coil with the secondary on the inside, and the formers available make the winding diameters $8\frac{1}{8}$in. (20.5 cm.) and $9\frac{1}{16}$in. (23 cms.), hence $c = 1.12$. A suitable ratio for the primary (outer) coil would be $x/A = 1.2$ (making the length 10.9in.) ; in this example the outer coil is the longer. To obtain the maximum k we make the inner coil half the length of the outer, so that $l/a = 0.67$.

Hence from Fig. 10, $F_o = 0.0061$, and $F_i = 0.0088$. Also from Figs. 4 or 5, $P = 0.0107$ when $c = 1.2$. The multiplying factor obtained from Fig. 6 is 1.07 so that our actual P will be 0.0115.

Applying equation (14)

$$k = \frac{0.0115}{2\sqrt{1.12 \times 0.0061 \times 0.0088}} = 0.74$$

Assume $q = 0.75$, then working equation (24) we have

$$\frac{83}{24} = 3.46 = \frac{0.74 \times 1.12^{\frac{3}{2}}}{1.75} \cdot \frac{n_o}{n_i} \quad \therefore \quad \frac{n_o}{n_i} = 7.5$$

From equation (25)

$$L_o = \frac{90}{2\pi \times 200 \times 10^3 \left[1 - \frac{0.55}{1.75}\right]} = 105\,\mu\text{H}$$

hence, from equation (10),

$$n_o^2 = \frac{105}{0.0061 \times 23} = 752 \text{ or } n_o = 27.5$$

thus n_i must be 3.65. In practice we make these 28 and 3.5 respectively. The actual value for L_i will thus be $0.0088 \times 20.5 \times 3.5^2 = 2.2\,\mu$H making $q = 0.7$ so our guess of 0.75 was near enough and we need not re-work. L_o will be $0.0061 \times 23 \times 28^2 = 110\,\mu$H.

The coil is now designed, but a check can be made on M which is given by equation (6), viz. : $M = 0.0115 \times 10.3 \times 3.5 \times 28 = 11.6\,\mu$H.

The current ratio we shall actually obtain will be

$$\frac{I_2}{I_1} = \frac{0.74 \times 1.12^{\frac{3}{2}}}{1.7} \times \frac{28}{3.5} = 3.8$$

giving a secondary current of 90 amperes.

Measured results on such a coil are given for comparison below and it will be seen that agreement is good.

	L_i	L_o	M	k
Calculated	2.2	110	11.6	0.74
Measured	2.5*	109	11.5	0.70*

7. Variometer Design

Certain details regarding the design of variometers for optimum performance are generally known, but will be recapitulated here for the sake of completeness on this

* L_i was difficult to measure accurately on the actual coil due to its low value and this also gives a corresponding error in k. As calculation of self-inductance can be made accurately it is felt that the calculated values are the true ones, especially as the values for M agree.

treatment of coupling coil design. It will be shown how simple and rapid the calculations become by the use of the curves now published and an example is quoted to verify the accuracy of the working.

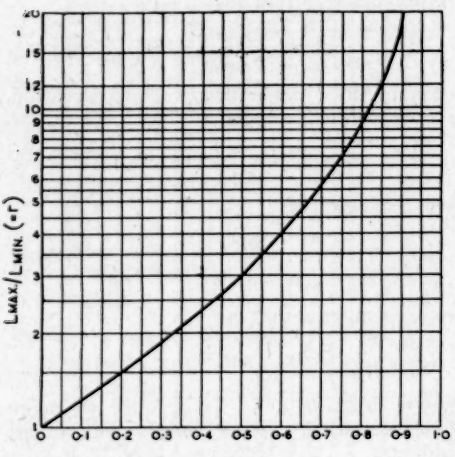


Fig. 15. *L_{max}/L_{min} plotted against k, for variometer (when inductances of both coils are equal).*

In a variometer, we aim to get the maximum ratio of inductance between the extreme positions of the rotor. Denote these values by L_{max} and L_{min} and their ratio by r. Let the ratio between the inductance of inner and outer coil be p so that $L_i = pL_o$. Then since

$$k = M/\sqrt{L_i L_o}, \quad M = k\sqrt{L_i L_o} = kL_o\sqrt{p}$$

hence

$$r = \frac{L_{max}}{L_{min}} = \frac{L_i + L_o + 2M}{L_i + L_o - 2M} = \frac{p + 1 + 2k\sqrt{p}}{p + 1 - 2k\sqrt{p}} \quad .. \quad .. \quad (27)$$

Differentiating equation (27) and equating to zero shows that r is a maximum when $p = 1$, i.e., we obtain the maximum change of inductance when the self-inductances of inner and outer coils are made equal. When this is done $L_i = L_o = L$, say, then

$$M = kL \quad .. \quad .. \quad .. \quad (28)$$

$$L_{max} = 2L\,(1 + k) \quad .. \quad .. \quad (29)$$

$$L_{min} = 2\,L\,(1 - k) \quad .. \quad .. \quad (30)$$

$$r = \frac{L_{max}}{L_{min}} = \frac{1 + k}{1 - k} \quad .. \quad .. \quad (31)$$

$$L_{var}^{*} = L_{max} - L_{min} = 4M = 4kL \quad (32)$$

$$\frac{L_{var}}{L_{min}} = \frac{2k}{1 - k} \quad .. \quad .. \quad .. \quad (33)$$

r depends on k alone and not on the actual values of the self-inductance of the windings.

In Fig. 15 is plotted the value of r against k, for the case of $p = 1$, so that if one sets out to design a coil with a given ratio of maximum to minimum inductance one can see what value of k the coil must have.

To show how the ratio r falls off as p is made other than 1, Fig. 16 has been plotted from equation (27) for two values of k. Serious loss of ratio apparently will not occur even if p ranges between 0.8 and 1.2.

From the previous work on coupling coils we found that k was a maximum when the two coils were made of equal length. Also for this condition, at least up to $c = 1.4$, we may take $F_o/F_i \therefore \sqrt{c}$. Thus, as L_i is to be made equal to L_o, equation (26) reduces to

$$1 = \frac{1}{c^{3/2}}\left(\frac{n_i}{n_o}\right)^2 \quad \text{or} \quad \frac{n_i}{n_o} = c^{\frac{1}{4}} \quad .. \quad (34)$$

which is the ratio by which we should relate the number of turns on inner and outer coil to obtain the same inductance on each. As

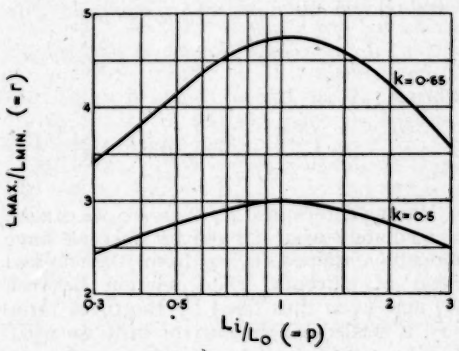


Fig. 16. *Illustrating variation of L_{max}/L_{min}, for variometer, with change in ratio of coil inductances.*

we saw that L_i/L_o could vary between 0.8 and 1.2 without seriously affecting r, it will be appropriate, in practice, to make.

$$\frac{n_i}{n_o} = c \quad .. \quad .. \quad .. \quad .. \quad (35)$$

i.e., the ratio of turns equal to the inverse ratio of coil diameters.

In this case, equation (6) reduces to

$$M = P \,.\, a \,.\, c \,.\, n_o \,.\, n_o = PA\, n_o^2 \,.. \quad (36)$$

In designing a variometer our starting

* The variation of inductance between the extreme positions.

point will depend upon the conditions to be fulfilled. We may either :—

(i) Decide on attaining a given value of r only. k is then obtainable directly from Fig. 15 and reference to Fig. 12 will then show the coil ratios to be adopted to achieve this.

(ii) Decide that we only need a given value of L_{var}, e.g., to cover the steps of inductance in an associated tapped coil. kL is obtainable then from equation (32) and suitable coil ratios can be determined from Fig. 12 to obtain a suitable k. If the coil sizes are fixed then k is obtainable again from Fig. 12 and it only remains to adjust the turns to give the necessary value of L.

(iii) Decide that L_{min} must not be greater than a certain value to allow the circuit to tune to a given highest frequency. In this case equation (30) will give the value of L required if a suitable value of k is chosen by reference to Fig. 12.

(iv) Decide that conditions (ii) and (iii) must both be fulfilled, i.e., a definite variation of inductance is required to cover taps in an associated coil and also the minimum inductance must not exceed a certain value to allow the circuit to tune to the highest frequency. Here equation (33) would show the value of k required immediately and reference then to Fig. 12 will give the coil ratios necessary to attain this. Substitution of k in equation (30) or (32) will then give the value of L to be adopted and the use of Fig. 10 allows the number of turns to be obtained.

Example.—To illustrate the ease with which the calculations may be carried out we take an example covering case (iv).

It is desired to construct a variometer with a variation of inductance of 80 μH (to cover 70 μH steps in an associated tapped coil) and in which L_{min} must not exceed about 20 μH to permit tuning to the highest frequency with the variometer, alone, in circuit.

Then from equation (33), $\frac{80}{20} = \frac{2k}{1-k}$ whence $k = 0.66$. The formers available for our coil have diameters of 8in. and 10in. respectively making the winding diameters 8.1in. (20.5 cms.) and 10.1in. (25.6 cm.), hence $c = 1.25$. From Fig. 12, we see that this value of k can be obtained at $x/a = 0.50$ for the given value of c. The length was therefore made 4in. (so x/a is actually 0.49).

From equation (32), $L = \frac{80}{4 \times 0.66} = 30.5\,\mu$H.

From Fig. 10, for $l/a\,(= x/a) = 0.49$, $F_i = 0.01045$. $\therefore n_i^2 = \frac{30.5}{20.5 \times .01045} = 142$

whence $n_i = 11.9$; in practice we make this 12 turns (giving $L_i = 31\,\mu$H). Hence from equation (35) $n_o = 9.6$ turns, which we make 10 turns in practice, so that actually L_o would be 30.5 μH. The coil is now virtually designed and will have the following dimensions :—

Outer coil former, 10in. dia., 4in. long, wound with 10 turns.

Inner coil former, 8in. dia., 4in. long, wound with 12 turns.

We can, however, make a check on the final expected results by obtaining the value of M. From Fig. 8, for the given values of c and x/a we obtain $P = 0.0166$, hence from equation (6) $M = 0.0166 \times 10.2 \times 10 \times 12 = 20.2\,\mu$H, and, therefore, $k = \frac{20.2}{\sqrt{31 \times 30.5}} = 0.66$, agreeing with the value we found to be necessary. The calculated values for the coil are then as given in the table below, whilst the measured values on a coil made up to this design are given in the second row. Agreement is good and shows that this simplified method of calculation is capable of giving quite accurate results both in variometer design and the working out of mutual inductance.

	L_{max}	L_{min}	L_{max}/L_{min}	L_i	L_o	M	k	L_{var}
Calculated ..	102	21.1	4.8	31	30.5	20.2	0.66	80.8
Measured ..	102.9	21.7	4.75	31.7	31.2	20.3	0.65	80.2

STABILISATION OF FEEDBACK OSCILLATORS*

By H. Jefferson, B.A., A.Inst.P., A.M.I.E.E.

THIS paper provides a general statement of known principles in oscillator design. It was prepared after rereading the account by Stevenson†, but an alternative method of analysis has been adopted which is, in the opinion of the writer, both simpler and more flexible than the determinant method. The advantages of the method are the justification for this fresh study of the problem.

It is known that in general a valve oscillator circuit will suffer changes in frequency when alterations of heater and anode supply voltages are made. These frequency changes are the result of changes in the grid-cathode and anode-cathode impedances, and a number of circuits have been described in which elements, redundant to the oscillation function, have been included to provide stabilisation of frequency against such changes. An alternative method of ensuring constancy of frequency is the correct use of a "very good" frequency-determining circuit, that is one having a very high Q. This fails if an adjustable frequency is required, for in general such circuits cannot be made with continuously variable frequency, as mechanical elements, quartz crystals or tuning forks, are needed. Even when high Q circuits are used there may be some advantage in stabilisation; the residual variations in frequency will be reduced, although the order of magnitude of these variations will already be low.

In this analysis we shall treat only the one-valve oscillator. We shall follow Stevenson in the assumption that all the circuit elements, except the valve resistances, are absolutely linear, and that the valve resistances are linear but variable in magnitude with variation of oscillation amplitude. This amounts to determining the state of affairs when the oscillations are of infinitely small magnitude, arranging the circuit so that the valve resistances do not affect the operation, and then allowing the amplitude to grow. The mechanism whereby the amplitude is limited at some finite value will not be considered, though it will be assumed that it has no effect upon the frequency. The assumption that the circuit elements are all lumped will not be made, though it will be assumed that transit-time effects are negligible. The basic circuit under consideration thus consists of a feedback network connected between output and input of a single valve, and this valve can be replaced by an equivalent generator of open-circuit voltage $-\mu e_g$, where μ is a pure number.

Before considering the feedback oscillator, two terms used will be defined. A stabilised oscillator is one in which an additional element (or elements) redundant to the oscillation function have been incorporated to make the frequency of oscillation independent of valve parameters. A potentially stable oscillator is one in which elements are included which would stabilise the frequency in the sense given above, but in which the elements are not necessarily so proportioned as to produce stability. It will be shown that oscillators using a minimum number of reactances are not potentially stable; that is, they are necessarily unstable.

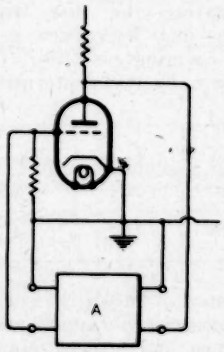


Fig. 1.

In Fig. 1 the basic circuit of a feedback oscillator is shown. A valve having a grid-cathode a.c. resistance R_2, amplification factor μ and anode a.c. resistance R_1, is connected to the input terminals of a network A. The output terminals of this network are con-

* MS. accepted by the Editor, March, 1945.

† *Bell S. Tech. Journ.*, Vol. XVII, p. 458 (July, 1938.)

nected back to the valve grid and cathode. Any anode load resistance is merged into R_1, and any grid leak is incorporated in R_2; the valve capacitances are included in the network A. Stabilisation is directed towards making the frequency of oscillation dependent only on the parameters of the network A, so that variations of the resistances R_1 and R_2 will not affect the frequency of oscillation, although changes of

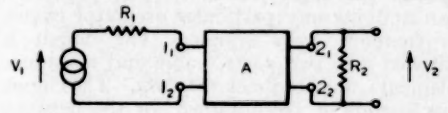


Fig. 2.

valve capacitance due to supply variations may do so. In the specific circuits examined, valve capacitances are ignored. A functional circuit is shown in Fig. 2. Here a generator of voltage V_1 and impedance R_1 drives the network at terminals 1_1 and 1_2, and the output of the network appears across R_2 at terminals of 2_1 and 2_2. This output voltage V_2 controls the generator voltage V_1. Any negative feedback, such as would be produced, for example, by an undecoupled cathode resistor, is taken into account in the derivation of the valve equivalent generator.

The network is by definition a passive linear network. If it alone is considered, it must have the basic form of Fig. 3. Two terminals, the input terminals, have applied to them a voltage E_1, and a current I_1 flows in at 1_1 and out again at 1_2. At the output terminals there exists a voltage E_2, and a current I_2 flows out at 2_1 and back again at 2_2. The senses are indicated by arrows in Fig. 3; the actual meaning attached to an arrow is immaterial, so long as the same meaning is adopted throughout*. The voltages and currents satisfy the general circuit equations:

$$\left.\begin{aligned} E_1 &= A_{11}E_2 + A_{12}I_2 \\ I_1 &= A_{21}E_2 + A_{22}I_2 \end{aligned}\right\} \quad .. \quad .. \quad (1)$$

The four quantities A_{11}, A_{12}, A_{21} and A_{22} are characteristic of the network, and if the network is passive satisfy also

$$A_{11}A_{22} - A_{12}A_{21} = 1 \quad .. \quad .. \quad (2)$$

A short discussion of this form of network equations was given in this journal a few months ago*.

If this network is connected in the circuit of Fig. 2, the ratio of generator voltage to output voltage is found to be

$$\frac{V_1}{V_2} = A_{11} + \frac{A_{12}}{R_2} + A_{21}R_1 + A_{22}\frac{R_1}{R_2} \quad (3)$$

In this equation V_2 is the voltage applied to the grid, and V_1 is the resulting generator voltage. Consequently $V_1 = -\mu V_2$ and the steady state oscillation condition is:

$$-\mu = A_{11} + \frac{A_{12}}{R_2} + A_{21}R_1 + A_{22}\frac{R_1}{R_2} \quad .. \quad .. \quad (4)$$

This equation is the fundamental equation of our oscillator: from it all the required information can be derived. First, however, it will be convenient to examine the nature of the A's. It will be assumed that the network consists of pure reactances only: this approximates to the most useful forms of stabilised oscillator. It is known† that any symmetrical four-terminal network, considered as a two-terminal pair, may be replaced by a lattice which is completely equivalent. In the application we are considering an ideal transformer must be added to avoid short-circuiting one arm by the common cathode connection 1_2 and 2_2. The actual form of the lattice equivalent to any particular network can be derived by the use of Bartlett's Bisection Theorem.‡ It is therefore sufficient to establish a result for a lattice to be sure that it holds for all symmetrical networks. Extension of the results below to dissymmetrical networks is difficult by this method, and the reader is referred to Gewertz, "Network Synthesis," for a formal approach. For the lattice network we proceed as follows:

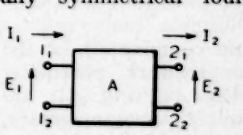


Fig. 3.

The network parameters are known to be:

$$\begin{aligned} A_{11} &= A_{22} = (Z_1 + Z_2)/(Z_2 - Z_1) \\ A_{12} &= 2Z_1Z_2/(Z_2 - Z_1) \\ A_{21} &= 2/(Z_2 - Z_1) \end{aligned}$$

* The convention usually adopted is that arrows representing current are in the direction of the current, but arrows representing potential difference are in opposition to the electric field, *i.e.*, from negative to positive. Thus when the E's have positive sign, terminals 1_1 and 2_1 are positive relative to 1_2 and 2_2 respectively.

* *Wireless Engineer*, Vol. XXI, p. 563 (December, 1944).

† Cauer, *E.N.T.*, No. 7, p. 279 (1929).

‡ A. C. Bartlett, "Theory of Electrical Artificial Lines and Filters," p. 28.

where Z_1 and Z_2 are the lattice arms. By Foster's Theorem*, both Z_1 and Z_2 must be of one of the general forms :—

$$\pm j\omega H \frac{(\omega^2-\omega_1^2)(\omega^2-\omega_3^2)\ldots.(\omega^2-\omega_p^2)}{(\omega^2-\omega_2^2)(\omega^2-\omega_4^2)\ldots.(\omega^2-\omega_q^2)}$$

or

$$\pm \frac{H}{j\omega} \frac{(\omega^2-\omega_1^2)(\omega^2-\omega_3^2)\ldots.(\omega^2-\omega_p^2)}{(\omega^2-\omega_2^2)(\omega^2-\omega_4^2)\ldots.(\omega^2-\omega_q^2)}$$

where $j=\sqrt{-1}$, H is a constant, ω is the angular frequency, $2\pi f$ and ω_1, ω_3 . . . ω_p are the ω values at which the function has zeros, and ω_2, ω_4 . . . ω_q are the ω values at which the function has poles. It is necessary, for the Foster form to represent a physically realisable impedance, that poles and zeros should alternate, that is, that

$$0<\omega_1<\omega_2<\omega_3 \ldots .$$

This form is applicable even if Z_1 and Z_2 are not made up of lumped elements, for the infinite product form of the tangent function, which appears in uniform line problems, is

$$x\frac{(1-\frac{x^2}{2^2})(1-\frac{x^2}{4^2})\ldots.}{(1-x^2)(1-\frac{x^2}{3^2})\ldots.}$$

If we substitute any combination of the Foster forms in the network parameter equations we find that A_{11} and A_{22} are always real, and A_{12} and A_{21} pure imaginary. This, it must be repeated, holds only because the elements are assumed to be pure reactances.

If (4) is examined, it is seen that it can be split into two equations by separation of real and imaginary terms giving :—

$$\left.\begin{aligned}\frac{A_{12}}{R_2}+A_{21}R_1&=0\\ A_{11}+A_{22}\frac{R_1}{R_2}&=\mu\end{aligned}\right\} \quad \ldots \quad \ldots \quad (5)$$

As we have seen, A_{12} and A_{21} are pure imaginary. In the reactance expressions the imaginary coefficient j appears always combined with an angular frequency term ω. The first equation of (5) must therefore be an equation involving frequency : it is therefore to be expected that this equation should be a frequency determining equation, while the second equation determines whether in fact sustained oscillations can take place. If the system is initially at rest and is then shock-excited, giving a response of the form $\epsilon^{\alpha+j\omega t}$, the first equation determines ω, and the second determines whether α will be positive or negative. For stabilisation, the frequency must be independent of R_1 and R_2 : this can only be so if

$$A_{12}=0, \text{ and } A_{21}=0$$

These two equations determine the frequency of oscillation and also the element proportions which will ensure stability with change of supply voltages. The procedure for studying any particular oscillator circuit is therefore very simple. The circuit is divided into two parts, valve and resistance elements, and feedback network. The circuit parameters A are obtained for the network alone, and the three equations :

$$\left.\begin{aligned}A_{12}&=0\\ A_{21}&=0\\ A_{11}+\frac{R_1}{R_2}A_{22}&=-\mu\end{aligned}\right\} \quad \ldots \quad \ldots \quad (6)$$

are examined. The first two together settle frequency and stability, and the third determines whether in fact the circuit gains and phases are such that oscillations can be maintained.

One further result is needed. The A's are related to the short circuit and open circuit impedances of the network by the formulae :—

$$A_{11}=Z_{oc.1}/[Z_{oc.1}(Z_{oc.2}-Z_{sc.2})]^{\frac{1}{2}}$$
$$A_{12}=Z_{sc.1}.Z_{oc.2}/[Z_{oc.2}-Z_{sc.2}]^{\frac{1}{2}}$$
$$A_{21}=1/[Z_{oc.1}(Z_{oc.2}-Z_{sc.2})]^{\frac{1}{2}}$$
$$A_{22}=Z_{oc.2}/[Z_{oc.1}(Z_{oc.2}-Z_{sc.2})]^{\frac{1}{2}}$$

By the use of the methods of matrix algebra it is possible to arrive more easily at the values for the general circuit parameters.*

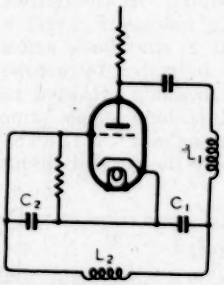


Fig. 4.

The results derived above may appear to be unnecessarily formal and mathematical. In fact, however, they provide a very quick and easy method of testing an oscillator circuit for potential stability, and of determining the stability conditions in a potentially stable circuit.

As an example we shall consider the stabilised form of the Colpitts circuit. The basic circuit is shown in Fig. 4 and from

* R. M. Foster, A Reactance Theorem, *Bell S. Tech. Journ.* (April, 1924.)

* *Wireless Engineer*, loc. cit.

this it can be seen that the feedback network is of the form shown in Fig. 5. This circuit is generally considered to be derived from the normal Colpitts circuit by the addition of a stabilising element L_1.

The parameters of the feedback network are found to be :—

$$A_{11} = (1 - \omega^2 L_1 C_1)(1 - \omega^2 L_2 C_2) - \omega^2 L_1 C_2$$
$$A_{22} = 1 - \omega^2 L_2 C_1$$
$$A_{12} = j\omega[L_2(1 - \omega^2 L_1 C_1) + L_1]$$
$$A_{21} = j\omega[C_1(1 - \omega^2 L_2 C_2) + C_2]$$

As we have seen, the frequency and stability condition are obtained by equating A_{12} and A_{21} to zero. If we do this, we find, excluding the trivial solution $\omega = 0$,

$$L_1 C_1 = L_2 C_2$$
$$\omega^2 = \frac{1}{L_2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$$

Thus the frequency is independent of L_1, and this inductance functions solely as a stabilising element.

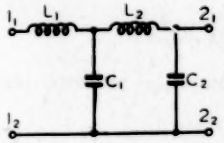


Fig. 5.

Further information about this oscillator circuit can be obtained by consideration of the "condition for oscillation" equation of (6). If, in this equation we write $R_1/R_2 = n$, the equation becomes $A_{11} + nA_{22} = -\mu$, or on substitution of particular values,

$$(1 - \omega^2 L_1 C_1)(1 - \omega^2 L_2 C_2) - \omega^2 L_1 C_2 + n(1 - \omega^2 L_2 C_1) = -\mu.$$

Using the value of ω^2 already derived, and the stability condition $L_1 C_1 = L_2 C_2$, this simplifies to

$$\mu = \left(\frac{C_1}{C_2}\right)n + \left(\frac{C_2}{C_1}\right)$$

or

$$n = \left(\mu - \frac{C_2}{C_1}\right)\left(\frac{C_2}{C_1}\right)$$

The value of μ given is that which will just maintain oscillations : it is a minimum when $(C_2/C_1)^2 = n$, when the value of μ required is $2(C_2/C_1)$. A greater value will result in oscillations of amplitude increasing until either overloading or some other form of limiting action brings the average μ value down to the steady state level. There will usually be some advantage in using optimum C_2/C_1 ratio, for then the maximum amount of negative feedback round the valve can be incorporated.

Another interesting result is quickly derived. If the oscillator is only potentially stable, the equation $A_{12}/R_2 + A_{21}R_1 = 0$ determines the frequency. For the Colpitts circuit, we find that :

$$\omega^2 = \frac{L_1 + L_2 + R_1 R_2(C_1 + C_2)}{L_1 L_2 C_1 + R_1 R_2 L_2 C_1 C_2}$$

differentiating,

$$\frac{d\omega}{\omega} = \frac{(L_1 C_1 - L_2 C_2)}{(L_1 + R_1 R_2 C_1)[L_1 + L_2 + R_1 R_2(C_1 + C_2)]} \times \left(R_2 \cdot \frac{dR_1}{R_1} + R_1 \cdot \frac{dR_2}{R_2}\right)$$

The term $(L_1 C_1 - L_2 C_2)$ can be considered to be an instability coefficient, for it provides a measure of the fractional frequency deviation when variation of the resistances R_1 and R_2 takes place. This is a useful expression for determining how closely $(L_1 C_1 - L_2 C_2)$ must approach the ideal value of zero, and thus helps in deciding the tolerances which can be allowed in the component values. It is useful also if the frequency is to be trimmed by the variation of a single element, as it enables an assessment to be made of the departure from the stabilised condition.

This discussion of a particular circuit has shown the power and simplicity of the method. Certain general aspects of feedback oscillators will now be considered. It is important to know what network configurations are potentially stable. For obvious practical reasons, unbalanced feedback circuits are invariably used. We shall, therefore, examine the conditions governing the basic networks.

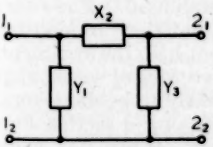


Fig. 6.

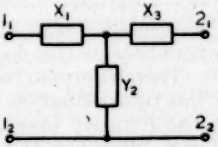


Fig. 7.

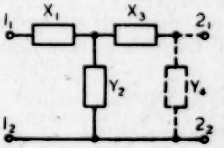


Fig. 8.

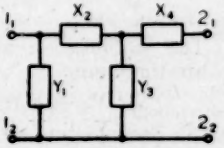


Fig. 9.

Choosing the π network of Fig. 6, in which

the admittances of the shunt arms are Y_1, Y_3 and the impedance of the series arm is X_2:

$$A_{11} = 1 + X_2Y_3$$
$$A_{12} = X_2$$
$$A_{21} = Y_1 + Y_3(1 + Y_1X_2)$$
$$A_{22} = 1 + Y_1X_2$$

From (6), $X_2 = 0$ and $Y_1 + Y_3 = 0$. These conditions can be met, but if they are inserted in the "condition for oscillation" equation, it becomes $1 + n = -\mu$, which is obviously impossible. It is therefore impossible to stabilise a π network oscillator, no matter how many elements are used in each branch. As might be expected, a similar result is obtained for the T network of Fig. 7, in which

$$Y_2 = 0\ ;\ X_1 + X_3 = 0\ ;\ 1 + n = -\mu$$

To make these networks potentially stable, an extra branch must be added. An additional branch to the T network can be either a shunt arm or a bridge arm. If the shunt arm is added as Y_4 in Fig. 8 we have the configuration of the stabilised Colpitts circuit, which we know already to have potentially

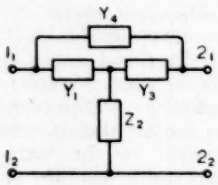


Fig. 10.

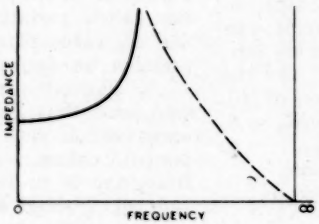


Fig. 11.

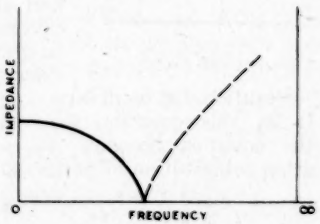


Fig. 12.

stable form. We shall therefore consider only the network of Fig. 9, leaving the study of the general form of Fig. 8 to the reader.

For the Fig. 9 network:

$$A_{11} = 1 + X_2Y_3$$
$$A_{12} = X_2 + X_4(1 + X_2Y_3)$$
$$A_{21} = Y_1 + Y_3(1 + Y_1X_2)$$
$$A_{22} = 1 + Y_1X_2 + Y_1X_4 + Y_3X_4(1 + Y_1X_2)$$

The stabilisation and frequency equations are therefore:

$$X_2 + X_4(1 + X_2Y_3) = 0$$
$$Y_1 + Y_3(1 + Y_1X_2) = 0$$

A particular solution of these equations is obtained when

$$Y_1 = j\omega C_1\ ;\ X_2 = j\omega L_2\ ;\ Y_3 = j\omega C_3\ ;\ X_4 = j\omega L_4$$

and is: $\omega^2 = \frac{1}{L_2}\left(\frac{1}{C_1} + \frac{1}{C_3}\right)$

$$L_2C_1 = L_4C_3$$

This will be recognised as similar in form to the result already derived above.

It will be profitable to examine why this extra branch is needed. At first sight it would appear that the T section of Fig. 8 could be transformed into a π section, and that the element Y_4 could then be merged as part of the shunt arm, leaving a potentially stable π network. If we examine the particular case we have already considered we shall see what happens.

The π elements equivalent to a given T section are

$$Z_1' = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_3}$$
$$Z_2' = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_2}$$
$$Z_3' = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_1}$$

where the prime indicates π network impedances and the suffixes are those used in Figs. 6 and 7. If $Z_1 = j\omega L_1$, $Z_2 = 1/j\omega C_2$ and $Z_3 = j\omega L_3$, we have

$$Z_2' = j\omega[L_1 + L_3 - \omega^2L_1C_2L_3]$$

This is not a realisable physical impedance, for its poles and zeros do not have the separation property required in Foster's theorem. Hence there is no realisable π equivalent to the T network to be stabilised. The other elements are realisable, but they are omitted here because this does not help the argument.

There is an alternative way of seeing that this transformation is likely to be dangerous. The iterative impedance of a π section low-pass filter has the form of Fig. 11, while that of a T section is of the form shown in Fig. 12. The mismatch conditions at the junction between section and stabilising element are thus altered, although the

T and π sections may have the same attenuation characteristic. We have replaced part of the feedback network by its dual: there is no justification for this.

The bridged T network can theoretically be stabilised. For the network of Fig. 10, the parameters are:

$$A_{11} = 1 + \frac{gY_3}{Z_2 + gY_4}$$

$$A_{12} = \frac{1}{dZ_2 + Y_4}$$

$$A_{21} = \frac{1}{Z_2 + gY_4}$$

$$A_{22} = 1 + \frac{gY_1}{Z_2 + gY_4}$$

where

$$g = 1/(Y_1Y_2 + Y_2Y_3 + Y_3Y_1);$$
$$d = 1/(Z_1Z_2 + Z_2Z_3 + Z_3Z_1)$$

The stability and frequency conditions become

$$\frac{1}{dZ_2 + Y_4} = 0 \quad \text{and} \quad \frac{1}{Z_2 + gY_4} = 0$$

It is possible to find impedances which will satisfy these equations, but the result is not very useful, for it depends on circuits having infinite Q. There is no saving of elements and it seems to be of academic interest only.

This survey of the problem has been made as general as possible, and it is hoped that the earlier parts are not unduly forbidding. The actual expressions used in any practical example are so simple that it is believed that the formal derivation of them is justified. To recapitulate: the test for stability of a feedback oscillator is performed by considering the feedback network alone. The equations relating input and output voltages and currents for this network are written down in a standard form, having been derived by any convenient method—Kirchhoff's Laws, Maxwell circulating currents or matrix algebra. The two parameters discussed above are equated to zero, and the resulting equations give the frequency of oscillation and the conditions for stability.

CORRESPONDENCE

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Signal/Noise Ratio

To the Editor, "Wireless Engineer."

SIR,—Mr. Callendar's letter in your April issue regarding my paper on "Triode Input Circuits" (in the February issue) raises points which are primarily of interest at frequencies higher than those originally contemplated. The object of my paper was to give a simple theory for moderate frequencies with a view to indicating the conditions in which the triode is advantageous. It was assumed that transit-time effects are negligible and consequently that R_g is high compared with the external impedances (R or R_2) connected to the grid circuit.

Analyses for the ultra-high-frequency case have been given by Herold (*R.C.A. Review*, January 1942, Vol. 6, pp. 302–331) for the normal amplifier, and by Dishal (Reference 3 of my paper) for the grounded-grid amplifier. It is assumed in these analyses that the input grid resistance is purely electronic and effectively at five times room temperature while the induced grid noise and the anode noise are in phase quadrature. In fact, however, the input resistance of many valves has an appreciable component due to lead effects (e.g., cathode or screen lead inductance) which will be noiseless. A treatment of the ultra-high-frequency case, therefore, requires considerable attention to the detailed structure of the valve if it is to be accurate.

Even assuming lead effects to be absent we still need a rigid and complete theory of noise in the space-charge-limited triode at frequencies where the transit angles are no longer negligible (*i.e.*, greater than about 1 radian).

R. E. BURGESS.

National Physical Laboratory.

Beat Detection

To the Editor, "Wireless Engineer."

SIR,—These correspondence columns are hardly the place to enter upon a dissertation on the well accepted facts of heterodyne phenomena, e.g., the obvious necessity for a detector to extract the beat envelope. But there is weighty authority for a view that modern mixers such as the triode-hexode involve a process of *modulation*, with production of sidebands, etc., in a case where there can clearly be no question of modulating one of two beating frequencies by the other.

A simple heterodyne between *two* frequencies f_1 and f_2 is characterised by the absence of anything equivalent to a carrier or sidebands—except in so far as f_1 and f_2 may themselves be sideband frequencies, as in a suppressed-carrier transmission.

The beat difference $(f_1 - f_2)$ is a modulation envelope, which has to be extracted by a detector in the ordinary way. The sum $(f_1 + f_2)$ will then also appear in the output, because it is the second harmonic of the resultant H.F. of frequency $\frac{1}{2}(f_1 + f_2)$.

The so-called "multiplicative" mechanism of

a triode-hexode involves no radical change in these fundamental principles—it is still the equivalent of a "First Detector," and a product term of the form $\sin \omega_1 t \,.\, \sin \omega_2 t$ does not necessarily imply modulation.

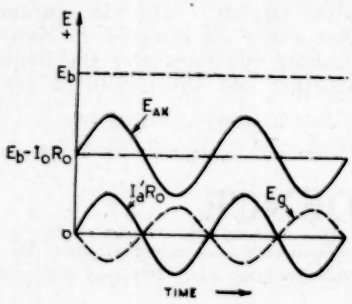
H. REES.

Withernsea, East Yorkshire.

Valve Vectors

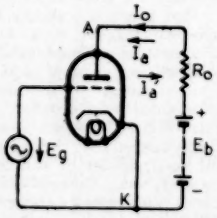
To the Editor, "Wireless Engineer"

SIR—I realised when I wrote "Valve Vectors" in the May issue of *Wireless World*, to which Prof. Howe referred in the June Editorial, that I was treading on dangerous controversial ground, and it is significant that my supporters gently chide me for my mistake in drawing Fig. 4(a) of my article, whereas my critics soundly belabour me for confusion of thought. I have no grounds of complaint against the critics because an author should see that his drawings are free from error. I have redrawn this figure as I meant it, and as Fig. 2(b) and the text of my article makes quite clear.



Only one of my critics, Mr. R. G. Wood, of Cardiff University, has given an adequate "conventional" alternative to my interpretation of the valve vector relationships. I am very much indebted to him for permission to publish his comparison of the two conventions. It will be seen that his convention agrees with Prof. Howe's mathematical analysis in the June Editorial.

Resistive Anode Load



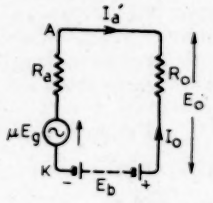
Sturley Convention

μE_g acting from cathode to anode inside the valve produces an alternating current I'_a flowing in the direction indicated. I'_a is in antiphase to the alternating component I_a actually flowing in the anode circuit, and during its positive half cycle *diminishes* the steady current I_0 flowing from the battery.

Total anode current at any instant

$$= I_0 - I'_a$$

of which the a.c. component is $-I'_a$.



Let $E'_0 = I'_aR_0 =$ alternating p.d. across R_0 due to I'_a. Then the voltage at the anode at any instant

$$= (E_b - I_0R_0) + E'_0$$

or $$E_{ak} = E_b - I_0R_0 + I'_aR_0$$

alternating component of the anode voltage

$$= +E'_0 = +I'_aR_0$$

Since the a.c. current produced in the load R_0 by μE_g is 180° out of phase with the actual alternating anode current I_a, and since, with a resistive load, E_g and I_a are in phase, it follows that μE_g and E_g must be in antiphase.

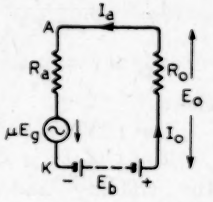
Wood Convention

μE_g acting from anode to cathode inside the valve produces an alternating current I_a flowing in the direction indicated. I_a is in phase with and, in fact, is the same as the alternating current actually flowing in the anode circuit, and during its positive half cycle it *increases* the steady current I_0 flowing from the battery.

Total anode current at any instant

$$= I_0 + I_a$$

of which the a.c. component is $+I_a$.



Let $E_0 = I_aR_0 =$ alternating p.d. across R_0 due to I_a. Then the voltage at the anode at any instant

$$= (E_b - I_0R_0) - E_0$$

or E_{ak}

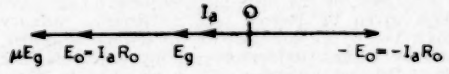
$$= E_b - I_0R_0 - I_aR_0$$

Alternating component of the anode voltage

$$= -E_0 = -I_aR_0$$

Since μE_g produces in R_0 in the equivalent circuit the same direction of alternating anode current as E_g produces, it follows that μE_g and E_g are in phase.

The "Sturley" vector relationship in which E'_0 = a.c. component of E_{ak}.



The "Wood" vector relationship in which $-E_0$ = a.c. component of E_{ak}.

It will be noted that the result is the same in both cases, i.e., the a.c. component of the anode-cathode voltage is 180° out-of-phase with the grid voltage producing it and the anode current component I_a is in phase. My convention involves reversing the fictitious anode current component I'_a to get the real anode current component I_a, and is due to the fact that the instantaneous anode current is $I_0 - I'_a$, of which the real a.c. component is $-I'_a$. Wood's convention involves reversing the

a.c. anode voltage component E_0 in order to get the actual anode-cathode component voltage. I leave readers to judge which convention they prefer. The "Wood" convention will be found in the "Admiralty Handbook" and several other English books, whereas my convention is used in Terman's "Radio Engineering" and many other American books.

Chelmsford, Essex. K. R. STURLEY.

Wave Trains

To the Editor, "Wireless Engineer."

SIR,—In many communication problems it is important that the number of effective oscillations in a damped, or, conversely, a growing wave train be known. This question frequently arises in transmissions involving the pulse excitation of circuits.

In these days engineers think of the selectivity of circuits in terms of Q, and there may be advantages in relating to Q, the number of effective oscillations in a wave train.

The relationship between the amplitudes of the initial and, what is considered to be, the last effective oscillation in a damped wave train can be given by

$$I_N = kI_1 \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where I_N is the amplitude of the last effective oscillation of the wave train, I_1 the amplitude of the initial oscillation of the train, and k an arbitrarily chosen constant having a value less than unity.

Usually k is taken as 1/100, but in the early days of radio it was taken as 1/10. It is now suggested that a more convenient value for k would be,

$$e^{-\pi} = 1/23 \text{ (approximately)} \quad .. \quad .. \quad (2)$$

Noting that $Q = \frac{\omega L}{R}$, and $\delta = \frac{\pi R}{\omega L}$ we have,

$$\delta = \frac{\pi}{Q} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (3)$$

where δ equals the Logarithmic Decrement of a circuit.

If N equals the number of effective oscillations in a damped wave train, then the value of N, as is well known will be given by,

$$1 + \frac{\log_e \frac{1}{k}}{\delta} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (4)$$

Substituting in (4) for δ in terms of Q as shown by (3) we have,

$$N = 1 + \frac{\log_e \frac{1}{k} \cdot Q}{\pi} \quad .. \quad .. \quad .. \quad (5)$$

Therefore, if $k = e^{-\pi}$,

$$N = 1 + Q \quad .. \quad .. \quad .. \quad .. \quad (6)$$

For most practical purposes (6) can be simplified to,

$$N = Q \quad .. \quad .. \quad .. \quad .. \quad .. \quad (7)$$

It can therefore be stated that when Q oscillations have occurred in a damped wave train, the amplitude of the wave train will be approximately 1/23 of its initial value.

A wave train such as this could be referred to as an "$e^{-\pi}$ wave train," and the converse type of train (i.e., a growing wave train) could be referred to as an "e^{π} wave train."

If k is given its present-day value of 1/100, we have from (5)

$$N = 1 + 1.46Q \text{ (approximately)} \quad .. \quad (8)$$

For most practical purposes this can be simplified to,

$$N = 1.5\,Q \quad .. \quad .. \quad .. \quad .. \quad .. \quad (9)$$

This latter type of wave train could be referred to as an "$e^{-4.6}$ wave train" — 4.6, being the Naperian logarithm of 1/100, the value chosen for k.

W. A. BEATTY.

London, W.13.

Book Review

Elektrische Schwingtöpfe und ihre Anwendung in der Ultrakurzwellen-Verstärkertechnik. (Klystrons and their use in ultra-short-wave amplification).

By ALFRED DE QUERVAIN. pp. 88 with 47 Figs. A.-G. Gebr. Leemann & Co. Zürich. 6 Fr. (Swiss).

This thesis is based upon two years' research work by the author at the Zürich Technical College. It deals with the design and use of "swing pots" i.e., klystrons in the place of ordinary oscillatory circuits in ultra-high-frequency work. After an introduction explaining what a klystron is, a chapter is devoted to the calculation of the losses, and thus of the Q-factor. Use is made of the principle of similitude in comparing the losses in similar klystrons of different sizes. High Q-factors are useless without stability and the question of temperature compensation is considered; if the linear dimensions are all multiplied by the factor m, the natural wavelength will be increased in the same ratio, but by the use of two metals of different coefficients of expansion it can be arranged that the general increase of linear dimensions due to a rise of temperature is associated with a relatively greater increase in the air-gap of the condenser, so that the natural frequency remains constant. A long section is devoted to the methods of coupling and matching klystrons to valves and to one another. There is a very interesting section showing how two adjacent klystrons can be coupled either capacitively or inductively by means of openings through which either the electric field or the magnetic field can fringe sufficiently to produce the necessary coupling. By means of adjustable slits the degree of coupling can be varied. Detailed drawings are given of the klystrons actually constructed and employed in a number of tests, the results of which are given; the wavelength is usually between 1 and 2 metres.

The thesis is well prepared and very free from typographical errors. On p. 18 l should be L; on p. 67 Philipps should be Philips, and in Fig. 29 an unfortunate mistake has been made by connecting the two coupling coils in parallel. On p. 72 the results are given of a number of measurements of resistance at high frequencies, but no attempt is made to compare these with the calculated values. The author may not be aware of the work that has been done on these lines. These are minor details, however, and the book is well worth the attention of anyone specially interested in klystrons.

G. W. O. H.

ABSTRACTS AND REFERENCES

Compiled by the Radio Research Board and published by arrangement with the Department of Scientific and Industrial Research

Comparative Length of the Abstracts.—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title; while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*

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PROPAGATION OF WAVES

2504. The Propagation of Electric Waves in a Rectangular Wave Guide.—E. B. Moullin. (*Journ. I.E.E.*, Part III, March 1945, Vol. 92, No. 17, pp. 8–17.)

Author's summary :—" This paper calculates the field, inside a rectangular wave guide, produced by a given set of currents at the origin. In particular, if the guide is excited by a single current filament on its mid-line then the field is found per unit current in this filament and also the radiation resistance of the filament. The solution is generalized to apply to a guide with a closed end. In Appendix 8.2 the field per unit current is calculated when the wave guide is very narrow, being then commonly called an attenuator. The solution for the guide is more complete than those which are common knowledge, in so far as the field is related to the current producing it, and this extension may be novel.

" In order to assess the sensitiveness of the classic solution to the exact form of the guide, the solution is found for a guide which has a vanishingly small taper. Then it is found that perfect cut-off cannot occur even when the width of the guide at the exciting filament is less than $\frac{1}{2}\lambda$: the explanation is that in such a guide of infinite length there is often a point at which the width exceeds $\frac{1}{2}\lambda$. It seems probable from this that complete cut-off will not occur if the generator is situated in a length of guide whose width is less than $\frac{1}{2}\lambda$, provided this length is joined to a guide whose width exceeds $\frac{1}{2}\lambda$.

" However, it appears that the expression for the radiation resistance of a current sheet, with sinusoidal loading, is general and applies to a guide having any taper, and in particular when the taper is zero and the sides have become parallel. It is concluded from this that the expressions for radiation resistance are very tolerant to small imperfections in the shape of the guide, and, in general, that the well-known and classic solution is very reliable for practical application, provided only that the cut-off property is not interpreted with complete rigour.

" For the sake of completeness the formal solution is recorded for a current filament at any point in a tapered guide which has a convex back of any radius; and also the solution for a current enclosed in a box having two sides which are arcs of concentric circles of any radius and two sides which are any radii of these circles. These two solutions are thought to be novel."

2505. Transformation of Electromagnetic Waves [and the Use of Branched Guides].—E. M. Studenkov. (*Journ. of Phys.* [of USSR], No. 6, Vol. 7, 1943: summary in *Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 112 and 162, 163.)

Probably the paper referred to in 705 of March. " In a wave guide, two opposite sides of which are rectangles and the other two sides of which are trapezoids, excited at its large end, standing waves of the H_{01} type may arise. Theoretically, wavelength and field intensity increase towards the small end of the guide. Experiments were carried out with a 32 cm wave and good agreement with the expected behaviour was observed. . . . When the shape of the cross-section of a hollow wave-guide varies, and in the case when it is bent, the type of the progressive wave suffers certain changes, which are the more considerable, the sharper the bend. These conditions suggested a method to transform waves of one type into those of another type by using horns having perpendicular branches. Experiments on these lines were carried out with waves from 8 to 11 cm. . . .

" By creating a standing E_0 wave in a circular guide having a perpendicular branch located exactly

at the place of the loop in the axial field of the E_0 wave, an H_1 wave was obtained in the branch which was polarised perpendicularly to the plane containing the axes of both guides. . . . The inverse transformation, *i.e.* the transformation of an H_1 wave into an E_0 wave, is also possible. In both instances, pure transformed waves were excited, no other waves than those intended being present. . . ." Other results are described, including the transformation of H_1 waves into H_0 waves (" of great practical interest ").

2506. Discussion on "Wave Guides in Electrical Communication" [3249 of 1943].—J. Kemp. (*Journ. I.E.E.*, Part III, March 1945, Vol. 92, No. 17, pp. 17–21.)

The discussion is mainly concerned with the possibilities of using wave guides for long-distance transmission. For the London discussion *see* 1007 of April: for the original paper *see* 3249 of 1943.

2507. Visualising Centimetric Waves [and the Behaviour of Wave-Guides & Horns: Audio Range of Sound Waves corresponds to R.F. Range of 3 cm to 300 cm (Wavelength of Sound Wave of Frequency 128 c/s in Air is approx. equal to Wavelength of 128 Mc/s Wave): " an Object affecting Both may be expected to exercise a Similar Effect "].—W. Bacon. (*Electronics*, June 1944, Vol. 17, No. 6, pp. 258, 260.)

2508. "Fields and Waves in Modern Radio" [Book Review].—S. Ramo & J. R. Whinnery. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 364, 366.)

2509. Very High-Frequency and Ultra-High-Frequency Signal Ranges as Limited by Noise and Co-Channel Interference.—K. A. Norton & E. W. Allen, Jr. (*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 86–87: summary of I.R.E. Winter Meeting paper.) This, presumably, is the report mentioned in 2356 of July.

2510. Very-High-Frequency and Ultra-High-Frequency Signal Ranges as Limited by Noise and Co-Channel Interference.—E. H. Armstrong. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 198, 200: Report of I.R.E. 1945 Winter Technical Meeting.)

Contains some useful transmission and service-area charts. The paper aroused so much interest that a special 2½-hour extra session was arranged.

2511. Measurement of V.H.F. Bursts.—F.C.C. (*Electronics*, Jan. 1945, Vol. 18, No. 1, p. 105.)

Sudden increases in the strength of signals received from frequency-modulated and television stations have been investigated by transmitting evenly spaced pulses. The distances of the bursts causing the increases in signal strength could then be found, and this helped to identify the origin of the bursts. It has been concluded that the bursts are not sufficiently prevalent to impair the usefulness of that portion of the v.h.f. spectrum in which they occur. *See* also 1719 of June.

2512. Strange Behaviour of F.M. Signals recorded [Notes on the "Long-Distance Bursts" (1719 of June) and "Sporadic-E Transmission"].—F.C.C. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 256..262.)

2513. Effect of Water Vapour in the Atmosphere on the Propagation of Ultra-Short Radio Waves.—S. S. Banerjee. (*Science & Culture* [*Calcutta*], April 1945, Vol. 10, No. 10, p. 453.)

The presence of water vapour in adequate quantity to saturate the air in the lower layers of the atmosphere can cause more than sufficient bending of ultra-short waves for propagation along the curvature of the earth. Such amounts of water vapour may be found in many places in India in the pre-monsoon and monsoon seasons.

2514. Absorption of Radio Waves in the Ionosphere.—J. Alpert & V. Ginsburg. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 383: in English, summary only: in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

"The exact solution of the wave equation in which absorption has been taken into account is discussed. The limitations of geometrical optics are discussed. Formulæ are given which permit one to determine the 'correlations' for the values of the optical path length and of absorption computed according to the formulæ of geometrical optics; it is shown that Appleton's formula for the mean number of collisions is valid in the majority of the practical cases. The nature of the absorption in the ionosphere is also discussed. Experimental investigations on absorption of radio waves in the ionosphere which could be found in the literature are examined."

2515. Fading Effects at High Frequencies.—Moore. (*See* 2602.)

2516. The Accuracy of Reception of Some Short-Wave Time Signals [and its Decrease with Increasing Distance].—W. Uhink & A. J. Corpaciu. (*Physik. Berichte*, No. 2/3, Vol. 25, 1944, p. 58.) Abstract of a Rumanian paper.

2517. The Refractive Index of an Ionised Gas (Ionosphere).—V. Ginsburg. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 383: in English, summary only: in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

"The necessity of incorporating the Lorentz 'polarization' correction in the expression for the force acting on an electron is investigated in a more vigorous manner than other authors have done up to the present. The analysis shows that the Sellmeyer–Larmor formula which does not take into account the Lorentz correction can be applied to the refractive index of the ionosphere."

2518. Suggested Interpretation of the Variations of Atmospheric Ozone with Latitude and Season, *and* Rôle of Temperature in the Distribution of Atmospheric Ozone.—A. Vassy & É. Vassy. (*Journ. de Phys. et le Radium*, April/June 1941, Vol 2, No. 2, p. S.23 onwards: July/Sept. 1941, No. 3, p. S.81 onwards.)

Comptes Rendus Notes were referred to in 640 of 1942. A summary of the present papers can be found in *Physik. Berichte*, No. 16, Vol. 24, 1943, pp. 1130–1131. It is concluded that the seasonal and geographical variations of e, the "reduced"

ozone amount $e = J.K(T)$, are due to the temperature dependence of the photochemical ozone equilibrium in the atmosphere. Three facts of observation support this hypothesis.

Finally, the writers derive by extrapolation, values for the seasonal ozone-distribution (never hitherto measured) in the polar regions, and discuss in detail the implications of the values obtained.

2519. The Temperature of the Upper Atmosphere.—A. Vassy & É. Vassy. (*Journ. de Phys. et le Radium*, Jan. 1942, Vol. 3, No. 1, p. 8 onwards.)

A long summary is given in *Physik. Berichte*, No. 16, Vol. 24, 1943, pp. 1131–1132. A *Comptes Rendus* Note, covering much of the same ground, was dealt with at some length in 989 of 1943; the present 9-page paper does not limit itself so much to the D-layer heights. A table is given representing the pressures and particle-numbers per unit volume calculated from the temperature curve, the upper atmosphere being assumed for this purpose to be divided into five layers each with a constant linear temperature gradient, at 30, 50, 80, 100 and 200 (winter) or 300 (summer).

2520. The Continental Effect in the Geographic Distribution of the Electron Concentration in the F_2 Layer.—V. N. Kessenikh & H. D. Bulatov. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 30th Nov. 1944, Vol. 45, No. 6, pp. 234-237: in English.)

"Without entering into a discussion on the nature of the seasonal changes in the electron concentration in the F-layer, one must acknowledge the following firmly established facts: (i) the average value of daily maxima of the electron concentration in the F_2 layer during the winter half of the year is higher than its average value during the summer half. This holds true both for the northern and southern hemispheres, though the seasonal difference for the latter is less pronounced. (ii) The increase in the average values of daily maxima of the electron concentration in the F_2 layer corresponds to the seasonal fall in the average temperature and rise in pressure in the troposphere. One is not permitted to assume that there is a direct causal relation between the seasonal changes in temperature, pressure and electron concentration. The possible considerations on the distribution of density and temperature with altitude are as yet too speculative in character to employ them to explain observed phenomena . . .

"In spite of incompleteness of the theory, the peculiarities in the seasonal course of the electron density in the F_2 layer may be regarded as regularly connected with the thermodynamics and aerodynamics of the atmosphere, and manifestation of these same regularities should be sought for not only in the seasonal change in the electron concentration, but in its geographic distribution as well.

"Already in 1935 Martyn & Pulley (317 of 1936) established the indicants of the correlation between the barometric pressure at the ground level and the critical frequency of the F_2 layer . . . More definite data on the correlation between meteorological processes and the critical frequencies of the F_2 layer were obtained by Bannon and others (2142 of 1940) during an analysis of synoptic charts of meteorological data in the region where the critical frequencies were measured (Australia). . . . A comparison of F_2 critical-frequency data obtained at Tomsk since 1936, with data from other ionospheric stations and with the climatic conditions of these stations, gives ground for asserting that the seasonal effect in the change of the electron concentration of the F_2 layer appearing in time is connected with a similar effect of climatic conditions in the geographic distribution of the electron concentration in the F_2 layer. For the conditions in the central part of Asia this effect assumes such a markedly pronounced form due to the continental climate of Siberia, that one may speak of the existence of a continental effect in the geographic distribution of the electron concentration in the F_2 layer, which is of the same nature as the seasonal effect . . ."

A diagram is presented showing monthly mean noon values of $f^0_{F_2}$ [averaged for 2 years] for Moscow and Tomsk. These two stations differ in latitude only by 30′ but the climatic conditions at the two sites are strikingly different. These curves of critical frequency values are compared with the variations in mean monthly atmospheric pressures for the two sites . . . "From this comparison it clearly follows that during the winter months, when the average pressure in Tomsk is considerably higher than in Moscow, the values of the critical frequencies in Tomsk are also considerably higher than in Moscow. In summer-time, when the pressures at these points equalise so do the critical frequencies . . . The existence of the continental effect, which may be established on the basis of the observation data of ionospheric stations in the USSR, most favourably situated for disclosing this effect, confirms the statement of Martyn *et al.*, that there is a fundamental connection between the seasonal effect in the F_2 layer and climatic conditions, and that the difference in the seasonal changes for various localities at the same latitude depends mainly upon climatic conditions."

2521. Solar Eclipses and Radio Investigations of the Ionosphere.—J. Alpert & B. Gorozhankin. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 382: in English, summary only: in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

"A discussion of radio investigations during solar eclipses is given (almost all papers on this subject having been considered). It is shown that important evidence on ionisation and deionisation processes in the ionosphere can be obtained during eclipses. In order to get more accurate quantitative data a large number of experiments would be required. As yet the effect of the corpuscular eclipse has not been ascertained.

This should be one of the fundamental problems for future radio observations. The desirability of investigation of the "geometry" of the layer during eclipses is emphasised. A short discussion is given of how the respective experiments should be carried out."

2522. An Estimation of the Integral Absorption in the Ionosphere according to Measurements of the Strength of Vertical Field.—V. N. Kessenikh. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 383: in English, summary only: in full

in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

" The experimental results are compared with the values of the field obtained by computing the radiation of a dipole placed between two conducting surfaces. It is shown that the corresponding formulae can be applied to estimate the coefficient of reflection of the ionosphere by using the results of measurement of the field strength. Evidence pointing to an increase of the absorption coefficient with increasing area of the sun spots is also given.

" It also follows from the experimental data that in those cases, in which the working frequency of layer E is close to the critical, no minimum of the field strength should be observed ; this may be due to the significant rôle played by partial reflection from the lower boundary of layer E."

2523. On Currents in the Ionosphere which Cause the Variations of the Terrestial Magnetic Field.—I. Tamm. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 383, in English, summary only : in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

" Three theories which have been proposed to explain the mechanism of appearance of ionosphere currents which cause the daily variations of the terrestrial magnetic field are discussed. The fallibility of two of the theories (Gann's and Chapman's) which was first mentioned by Cowling is proved in the general form. However, up to the present the Chapman theory of gravitational drift did not take into account the fact that the distribution of the ions in the ionosphere is an equilibrium one. By taking into account this circumstance a modification of the Chapman theory is suggested. Preliminary calculations indicate that this theory may yield the magnitude as well as the phase of the ionosphere currents."

2524. The Radiation Relations of a Rayleigh Atmosphere [Ideal, Clean Atmosphere composed only of Non-Absorbing Air Molecules : Part I—Calculations : Part II—Comparison of Calculated Results with Measurements by Knepple, Reitz, and Other Workers].—P. Hess & F. Linke. (*Meteorol. Zeitschr.*, Oct. 1942, Vol. 59, No. 10, p. 313 onwards : Nov./Dec. 1942, No. 11/12, pp. 364 & 400 onwards). For long summaries see *Physik. Berichte*, No. 16, Vol. 24, 1943, pp. 1135–1137 & 1137–1138.

2525. Cloud Heights and Densities [Daytime Measurements made Quickly and Accurately by Modulated Light and a Photoelectric Ceilometer].—P. H. Houser. (*Gen. Elec. Review*, April 1945, Vol. 48, No. 4, pp. 7–12.)

2526. Spicules [Small Solar Prominences] are Much More Frequent and Short-Lived than was previously Realised [Life-Time averages 4–5 Minutes : Most Commonly Seen in Polar Regions where Sunspots are Infrequent : are possibly a Link between Solar Granules & Polar Coronal Plumes].—W. O. Roberts. (*Sci. News Letter*, 24th March 1945, Vol. 47, No. 12, p. 183.)

2527. " What are Cosmic Rays ? " [Book Review].—P. Auger. (*Review Scient. Instr.*, April 1945, Vol. 16, No. 4, p. 84.)

2528. On the Existence of Electromagnetic-Hydrodynamic Waves [in Conducting Liquids in a Uniform Magnetic Field : Importance in the Formation of Sunspots].—H. Alfvén. (*Physik. Berichte*, No. 2/3, Vol. 25, 1944, p. 92.) For other work *see*, for example, 1625 & 2950 of 1943 and 1497 of 1944.

2529. On the Propagation of Radio Waves along an Imperfect Surface.—E. Feinberg. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, pp. 317–330 : in English.)

A method for investigating ground wave propagation along an uneven homogeneous surface is developed for the case of small gradients and deflections of the surface from an averaging plane, assuming the complex dielectric constant to be large. Inhomogeneity of the latter quantity must be small within an interval of the order of the depth of penetration of the field into the ground. Thus the theory generalises that of Sommerfeld for a plane homogeneous conducting earth, and deals primarily with the case of a vertical dipole placed on the surface of the earth.

The method may be used for investigating local perturbations, as well as for evaluating the function describing the average attenuation of the field. The conclusion is reached that in certain cases the surface may be characterised by an effective conductivity, which is complex and dependent on wavelength. Formulae for various limiting cases are given.

It is shown that for a " uniformly and isotropically corrugated inhomogeneous surface " the attenuation function is the same as that of Sommerfeld, substituting effective electrical parameters. Propagation along a surface with variable electrical parameters (true for a plane surface, effective for a corrugated surface) is reduced to an integral equation in one dimension.

2530. The Effective Path of Radio Waves.—E. Feinberg. (*ournn. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 382 : in English, summary only in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

" It is shown that for the propagation of radio waves along the earth's surface a narrow zone connecting the receiver and transmitter is of primary importance. It seems that the most significant influence is caused by those parts of the earth's surface which border with the ends of this path."

2531. On the Propagation of Radio Waves along the Real Surface of the Earth.—E. Feinberg. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 382 : in English, summary only : in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

" Propagation of radio waves along an uneven and inhomogeneous surface of the earth is considered. Consideration of inhomogeneous ground is carried out by applying and generalising Leontovich's method. The method proposed is valid for the case of sufficiently small slopes of the terrain. The solutions thus obtained permit one to rigorously investigate perturbations of the field due to local inhomogeneities and also to study the field below

an inhomogeneous and rugged surface. The problem of coastal refraction is completely solved in this work, the formulæ thus obtained can be easily discussed. It is shown that for a uniformly and isotropically uneven and inhomogeneous surface of the earth the weakening function coincides with that of Sommerfeld computed for effective electric parameters."

2532. Concerning a Certain Method for solving Problems of Propagation of Electromagnetic Waves along the Earth's Surface.—M. Leontovich. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 382 : in English, summary only : in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

"The fact that the modulus of the complex dielectric constant of the earth is much larger than unity is taken into account at the very start of the solution. This, first of all, permits one to use approximate boundary conditions on the surface of the earth ; secondly, and this is the main idea of the method, different length units which depend on the dielectric constant of the earth are introduced for the vertical and horizontal axes. Introduction of the corresponding undimensional units leads to a differential equation of the parabolic type for the function of the weakening of the field. Illustration of the Sommerfeld problem leads directly to the well known Weyl – van der Pol formula."

2533. Propagation of Electromagnetic Waves along a Single Wire.—V. Vladimirsky. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 382 : in English, summary only : in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

"The excitation of electromagnetic waves in a single infinitely long wire by concentrated electromotive forces is examined. The solution is reduced to a form which permits one to carry out radio communication calculations for a number of practical cases. A formula is given for the efficiency coefficient when communication is carried out over a single line."

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2534. Microwave Radiation from the Sun.—(*Bell Lab. Record*, April 1945, Vol. 23, No. 4, pp. 132–133.)

"In addition to establishing the fact that radiation at these wavelengths is received from the sun, the most important indication of this work is perhaps that more extensive study should be undertaken, and to the extent that time and circumstances will permit, such studies are contemplated. . . A full account of Dr. Southworth's studies . . . is appearing in the April issue of Journal of the Franklin Institute."

2535. The Rôle of the Ice-Bearing Clouds in Thunderstorms [Rejection of Theory of Separation of Charges as Cause of Thunderstorms, in favour of Induction Mechanism involving the "Innumerable Fine Points" of the Ice Crystals].—H. Rudolph. (*Physik. Berichte*, No. 1, Vol. 25, 1944, p. 45).

2536. The Electrical Phenomena of the Thunderstorm : Essay at a Critical Decision between the Various Thunderstorm Theories.—H. Israël. (*Physik. Berichte*, No. 1, Vol. 25, 1944, pp. 44–45.)

2537. Peculiar Accumulation of "Silent" Electrical Discharges at Approximately Regular Intervals [during a Minor Thunderstorm at Night, or associated with a Cold Invasion without Thunderstorm].—H. Israël. (*Physik. Berichte*, No. 1, Vol. 25, 1944, p. 45.)

2538. Lightning Strokes in Buried Cables.—H. Schmid. (*Rassegna d. Stampa Tecnica Tedesca* [Rome], July/Aug. 1942, Electrotechnics Section, pp. 232–233.)

2539. Discussions on "The Protection of Structures against Lightning."—J. F. Shipley. (*Journ. I.E.E.*, Part I, Sept. 1944, Vol. 91, No. 45, pp. 349–354.)

Summaries of the original paper were dealt with in 24 of 1944 : the whole paper appeared in the same *Journal*, Part I, Vol. 90, 1943, p. 501 onwards.

2540. The Unrest of the Electrical Field : Examples of the Influence of the Meteorological Conditions on the Behaviour of the Field at Ground Level.—H. Israël. (*Physik. Berichte*, No. 1, Vol. 25, 1944, p. 44.)

2541. Enemy Radiosondes [Comparison of German & Japanese Types with American].—(*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, p. 202 : *Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 224, 225.)

2542. Wet Cell developed for Radiosonde Sets ["Weighing a Pound when Charged and providing A & B Voltages of 3 & 90, respectively" : Infinite Shelf Life, compared with 6 Months for Dry Batteries].—U.S. Navy. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, p. 214 : paragraph only.)

PROPERTIES OF CIRCUITS

2543. Ultra - High - Frequency Converter Analysis.—Stockman. (*See* 2600.)

2544. A Theoretical and Experimental Investigation of Tuned-Circuit Distortion in Frequency-Modulation Systems.—D. L. Jaffe. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, pp. 318–333.)

"The problem of distortion introduced into the modulation intelligence by tuned circuits is considered both theoretically and experimentally." The parameters affecting distortion for various types of tuned circuit are the ratios of peak frequency-deviation to bandwidth, and modulation-frequency to bandwidth. For modulation frequencies up to 15 kc/s., distortion-free transmission is obtained for a bandwidth equal to four times the peak frequency-deviation.

2545. Wide-Range Tank Circuits for V.H.F. and U.H.F. [Simplified Mechanical Design for Amateur Construction].—M. L. Gable. (*QST*, April 1945, Vol. 29, No. 4, pp. 48–49.)

2546. Propagation of Electromagnetic Waves Along a Single Wire.—Vladimirsky. (*See* 2533.)

2547. Coaxial Cable Design.—N. D. Kenney. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 124–128).

Exact and approximate formulæ are given for determining the basic parameters of coaxial cable to facilitate the determination of the effects of conductors, dielectrics, and dimensions on electrical characteristics. Graphs indicate variations that can be expected from changes in materials and construction.

2548. Transmission-Line Conversion Transformers.—N. Marchand. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 142–145.)

Methods for joining a balanced two-wire line to a coaxial line are discussed. A conversion transformer at the junction can be ideal only at one frequency, but methods are described which provide satisfactory conversion over a 3 : 1 frequency range.

2549. The Application of Network Analysis to Some Electron Optical Problems. Prebus & Zlotowski. (*See* 2751.)

2550. Fields of Air-Core Coils and Applications to Radio-Frequency Heating.—Brown : Kirkpatrick. (*See* 2854.)

2551. A Search for V.F.O. Stability [Reducing Frequency Drift in Transmitter Oscillators].—C. L. Robinson. (*QST*, May 1945, Vol. 29, No. 5, pp. 18–21, and 80..82.)

2552. Band-Pass Filter Design [Charts for T & *Π* Band-Pass Sections].—C. J. Merchant. (*Electronics*, March 1945, Vol. 18, No. 3, p. 146.)

2553. High-and Low-Pass Filter Design [Elimination of Much of the Arithmetical Drudgery by use of Reactance Slide-Rule].—C. J. Merchant. (*Electronics*, Feb. 1945, Vol. 18, No. 2, p. 144.)

2554. *R-C* Filter Circuits.—G. J. Thiessen. (*Journ. Acous. Soc. Am.*, April 1945, Vol. 16, No. 4, pp. 275–279.)

"The limitations of *L-C* filters at low frequencies arise from the facts that the *Q* of an inductance becomes very low and the condensers of the required capacity are often as bulky as the inductances. The problem in *R-C* filters is one of getting the desired sharp cut-off features. In this paper an attempt is made to solve this problem with *R-C* components whose size would not be excessive even at frequencies as low as one cycle per second."

2555. Pi-Network Calculator.—W. G. Bruene. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 140–146.)

A graphical method of calculating reactances for a pi-network that will match a complex load to a given "tube plate circuit." Changes in the tube loading that are produced by varying the elements of the network can be studied directly from the calculator.

2556. Loaded Phase-Shifting Networks [Performance of Such Networks with Thyratrons or Other Loads across their Outputs].—P. T. Chin. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 146–148.)

2557. Double-Tuned Transformer Design [Fundamental Equations Plotted in General Form Showing the Relations between k, Q, db, f/f_0. Response at Resonance, and Attenuation : Examples Illustrate Use of Curves].—D. Espy. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 142–143.)

2558. Practical Design of Video Amplifiers. —Henry. (*See* 2598.)

2559. Zero Phase Shift Amplifier Design [Equations and Circuits for Design of Wide-Band Amplifiers having Extended Frequency Ranges of Flat Phase and Amplitude Response].—L. B. Malling. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 136–139.)

2560. Cathode Follower Calculations [Equations Relating Cathode Follower Output Impedance to Value of Cathode Resistor, Plate Load Resistor of Cathode Follower Tube, and Transconductance of Tube.] —H. P. Pacini. (*Electronics*, Oct. 1944, Vol. 17, No. 10, p. 137.)

2561. Polyphase Systems applied to R.F. [Several Simple Applications of Multiphase Excitation : Automatic Tuning of an Amplifier : Rotation of an Antenna Pattern].—R. W. Bickmore. (*QST*, March 1945, Vol. 29, No. 3, p. 11.)

2562. Discriminator Linearity. — Arguimbau. (*See* 2592.)

2563. Open-Grid Tubes in Low-Level Amplifiers.—R. J. Meyer. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 126–128 and 234.)

"For certain applications in amplifiers requiring a high input resistance and low noise level it has been found desirable to eliminate the grid leak, and no undesirable effects resulted from using the tubes in this manner. Examples of such applications are amplifiers operating from a low-level high-impedance source, amplifiers that must present the lowest possible load to the preceding stage, and amplifiers that must handle signal voltages of the same order as the noise level. Actually, operation of a tube with an open grid is less noisy than operation with a grid leak."

2564. The See-Saw Circuit : a Self-Balancing Phase-Splitter.—Scroggie : Philips Company. (*See* 2603.)

2565. Band-Width Requirements for Pulse-Type Transmissions [Discussion of Wave Shape as a Guide in Frequency Allocations]. —W. W. Hansen. (*QST*, Feb. 1945, Vol. 29, No. 2, p. 11.)

2566. Circuit Response to Non-Sinusoidal Wave Forms.—P. T. Chin. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 138–141.)

The article is based on a paper presented before the Chinese Institute of Engineers, American Section, on July 2, 1944. It deals with a short-cut method of determining the current response in

circuits energised by square, saw-tooth and similar waves. Instead of decomposing the wave into Heaviside unit functions, it can be decomposed into waves of other types which have the same wave form but start at different instants.

2567. Relaxation-Oscillation Generating Circuits for Frequency Dividing and for the Production of Impulse Voltages [with Special Attention to a Tetrode Circuit and Its Improvement by Use of a Hexode].—H. Bödeker. (*T.F.T.*, Feb. 1940, Vol. 29, No. 2, p. 44 onwards.) For a long summary see *Rassegna d. Stampa Tecnica Tedesca* [Rome], March/April 1940, Electrotechnics Section pp. 46–48.

2568. Coupling Coefficient Charts.—L. E. Pepperberg. (*Electronics*, Jan. 1945, Vol. 18, No. 1, p. 144.)

The coupling coefficient of a radio-frequency transformer can be quickly determined by making two simple measurements with a Q-meter and the subsequent use of the chart provided. The measurements involve the connection of the Q-meter across the primary circuit of the transformer and tuning to resonance by variation of either the frequency or the Q-meter capacitance with the secondary open- and short-circuited in turn.

2569. Impedance Conversion Chart [Complex Quantities from Rectangular to Polar Form or Vice-Versa, Using Straight-Edge: with Known Reactance and Resistance, Magnitude and Phase Angle of Impedance Quickly Determined].—P. H. Warf. (*Electronics*, Oct. 1944, Vol. 17, No. 10, p. 144.)

2570. Equivalent Triode Networks [Four-Terminal Networks Equivalent to Various Triode Connections].—H. A. Wheeler. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 304, 306, 308; Report of I.R.E. 1945 Winter Technical Meeting.)

2571. Electromechanical Equivalence.—H. Jefferson. (*Marconi Review*, April/June 1945, Vol. 8, No. 2, pp. 60–73.)

Author's summary:—"A general survey is given of the problem of the analogy between mechanical and electrical circuit elements. The essential duality, mentioned by other writers, is preserved throughout: clear guidance is given on the choice between duals. One equivalent, believed to be new, completes the system of simple mechanical elements, and enables any electrical structure to be transformed into a mechanical system. A shortened version of this paper appeared in the *Wireless Engineer*, December, 1944."

2572. Constant-Impedance Control [Suggested Circuits for maintaining Practically Constant Impedance with a Minimum of Resistance Components].—J. C. Coe. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 160, 164.)

2573. Amplifier Theory applied to Regulators [Method of utilizing Equations for Negative Feedback Amplifiers to Design an Analogous Voltage Regulator System].—J. M. Cage. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 140–143.)

2574. Relays in Industrial Tube Circuits [Part I: Practical Survey of Available Methods for using Relays with Diodes and Triodes for On-Off Control Applications; Part II: Choice of the Most Sensitive Operating Point for a Vacuum Tube Relay].—U. R. Furst. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 134–137: Jan. 1945, Vol. 18, No. 1, pp. 136–138.)

2575. Differentiating and Integrating Circuits (Engineering and Laboratory Applications of Differentiating and Integrating Circuits: Anti-Hunting Circuits for Servo Mechanisms and Other Control Systems].—J. G. Clarke. (*Electronics*, Nov. 1944, Vol. 17, No. 11, oo. 138–142.)

2576. Gaseous Rectifier Circuits.—P. T. Chin. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 132–137.)

Second and concluding part—continued from April issue—of a paper presenting current and voltage wave-forms of commonly used rectifier circuits, with equations alongside the curves for convenient reference. Bi-phase arrangements of phanatrons and thyratrons are covered by the 22 sets of curves in this part.

TRANSMISSION

2577. Stable V.H.F. Oscillators: Design of a Tunable-Line Oscillator for 280–450 Mc/s.—B. J. Solley. (*Wireless World*, June, 1945, Vol. 51, No. 6, pp. 170–173.)

Required for laboratory use: capable of being amplitude or pulse modulated with inappreciable resultant f.m. content, and having smooth continuously-variable frequency adjustment, with minimum of controls. Choice of circuits is discussed at considerable length: the one adopted is intermediate in character between a Meissner and a Colpitts. One figure illustrating the stability attained is the maximum over-all calibration change over one year: 0.75 Mc/s over the range mentioned in the title. This includes changes due to mechanical factors associated with the tuning mechanism: an identical oscillator fitted with pre-set end cap and tuned to 400 Mc/s gave an over-all change of about 0.2 Mc/s at the end of a year.

2578. Vacuum-Contained Triode Transmitter [Pulse and C.W. Operation at 200–700 Mc/s provided by Triode with Transmission Line Built into Vacuum Tube].—H. A. Zahl, J. E. Gorham and G. F. Rouse. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 210, 214: Report of I.R.E. 1945 Winter Technical Meeting.)

2579. A Crystal-Controlled Transmitter of the V.H.F.s [Covering Amateur Bands on 14, 28, 56 and 112 Mc/s].—G. W. Brooks. (*QST*, May 1945, Vol. 29, No. 5, pp. 25–27.)

2580. A Theoretical and Experimental Investigation of Tuned-Circuit Distortion in Frequency-Modulation Systems.—Jaffe. (*See* 2544.)

2581. A Search for V.F.O. Stability [Reducing Frequency Drift in Transmitter Oscillators.]—C. L. Robinson. (*QST*, May 1945, Vol. 29, No. 5, pp. 18–21 and 80 . . . 82.)

2582. The Functioning of a Triode Oscillator with Capacitor and Grid Resistor [Investigation (Long Postponed) of the Exact Conditions in which Periodic Interruptions of Oscillation occur in Oscillators with Automatic Grid Bias through Resistance & Capacitance in Parallel].—J. van Slooten. (*Philips Tech. Rundschau*, Feb. 1942, Vol. 7, No. 2, p. 41 onwards.)

For an illustrated summary of this six-page paper see *Rassegna d. Stampa Tecnica Tedesca* [Rome], Nov./Dec. 1942, Electrotechnics Section pp. 376–377. A *Wireless Engineer* paper by the same writer (1418 of 1939) seems to cover the same ground.

2583. Supply Voltage Effect on Transitron Performance.—C. Brunetti. (*Communications*, Feb. 1945, Vol. 25, No. 2, pp. 60–64.)

2584. Non-Linear Distortion in Transmission Systems.—R. A. Brockbank & C. A. A. Wass. (*Journ. I.E.E.*, Part III, March 1945, Vol. 92, No. 17, pp. 45–56.)

Author's summary :—" The problem of the distortion noise generated by a signal in its transmission through one or more non-linear devices is analysed. This subject has become of increasing importance in connection with the development of the transmission of different types of signals on a multi-channel basis through a common network, e.g., modulator, amplifier or transmitter. The provision of such networks is now of frequent occurrence, and in order that economic and satisfactory designs may be obtained it is essential to be able to determine precisely the effect of non-linearity and also the limiting linearity requirements, preferably in a form which can be readily comprehended and applied by designers. The problem has been considered to be very complex, and existing literature is both scanty and involved. This paper presents a simple solution, which is capable, in general, of immediate application to any type of complex signal (e.g., speech, music, television, voice-frequency telegraphy or thermal noise) covering any frequency band or frequency allocation. The results are presented to the designer in the form of the limiting levels of the various harmonics of a single tone, which levels must not be exceeded if the noise power from the non-linear device in any specified frequency band is not to exceed a predetermined value. The differences in the linearity requirements of a single amplifier and of a repeatered system are demonstrated. Provided the input/output characteristic of the network can be expressed as a single-valued power series independent of the frequency in the working band, the results obtained should cover with adequate accuracy the design of all types of transmission systems."

2585. Engineering Economics [Multiplex Radio Transmission].—N. F. Schlaack & A. C. Dickieson. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 218..234 : Report of I.R.E. 1945 Winter Technical Meeting.)

Multiplex radio transmission promises the same savings as afforded by multiplex wire transmission. However, even with directive antennas, the required radio frequency power is large and costly. Efficiency is therefore of great importance. Schemes for spreadband operation have been used to avoid the most serious intermodulation products, but at the cost of greater bandwidth. Negative feedback can be applied to reduce intermodulation to a satisfactory value even at signal amplitudes approximating the rated output of the tube in the final transmitter stage.

RECEPTION

2586. Selectivity of Superregenerative Receivers [Contrary to Popular Opinion the Selectivity of a Very High Frequency Superregenerative Detector is better than can be obtained with Tuned Circuits].—A. Easton. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 284, 286 : Report of I.R.E. 1945 Winter Technical Meeting.)

2587. New Frequency-Modulation Converter [developed for Present 42–50 Mc/s F.M. Receivers if F.C.C.'s Proposed Change of Frequency Band to 84–102 Mc/s is carried through (*cf.* 2356 of July) : can be operated from Arm-Chair as Remote Tuner].—F.C.C. (*Sci. News Letter*, 24th March 1945, Vol. 47, No. 12, p. 188.) To be put on the market at about 11 dollars.

2588. Frequency Modulation [Letter replying to Comments by Gladwin & Thompson on an Earlier Letter of Bell's suggests that the Interference due to a Strong Impulse on an Accurately-tuned Carrier will be Small in a F.M. Receiver].—D. A. Bell. (*Wireless Engineer*, June 1945, Vol. 22, No. 261, p. 283.)

2589. An F.M. Receiver for Carrier-Current Communication [Receiver to Work in Conjunction with the Transmitter referred to in 1950 of June].—G. M. Guill. (*QST*, March 1945, Vol. 29, No. 3, pp. 46–47.)

2590. A Theoretical and Experimental Investigation of Tuned-Circuit Distortion in Frequency-Modulation Systems.—Jaffe. (*See* 2544.)

2591. Effect of Common-Channel Interference on Frequency-Modulation Broadcasting [Cause of Sudden Blanking-out by Distant Station on Same Frequency].—A. L. Durkee. (*Bell Lab. Record*, April 1945, Vol. 23, No. 4, pp. 137–139.)

2592. Discriminator Linearity [Correlation of Electrical Characteristics in Resonant Coupled Circuits and Staggered Cascade Circuits Demonstrated : Discriminator Action Explained and Conditions for Best Linearity Established].—L. B. Arguimbau. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 142–144.)

2593. Strange Behaviour of F.M. Signals recorded [Notes on the " Long-Distance Bursts " (1719 of June) and " Sporadic-E Transmission "].—F. C. C. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 256..262.)

2594. Visual Alignment of Wide-Band I.F. Amplifiers.—H. A. Cook & H. Moss. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 130–132.)

A production test-unit for the alignment of wide-

band amplifiers provides an amplitude-modulated signal for sensitivity measurements and a frequency-modulated signal for band-width adjustments. The response curves obtained are observed on an external cathode-ray oscilloscope.

2595. The Circuit Design of Intermediate-Frequency Amplifiers.—C. P. Beanland & G. L. Grisdale. (*Marconi Review*, April/June 1945, Vol. 8, No. 2, pp. 37–45.) Presents the salient features of practical design, already available, though not in such compact form, in various papers and books.

2596. Engineering Double-Superhet Receivers ["Choice of High First & Low Second Intermediate Frequency permits Design of Set entirely Push-Button Tuned"].—J. D. Reid, Jr. (*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 82–85.)

2597. The Functioning of a Triode Oscillator with Capacitor and Grid Resistor.—van Slooten. (*See* 2582.)

2598. Practical Design of Video Amplifiers [Part I—Causes of Frequency Attenuation: Low-Frequency Correction: Underlying Principles and Practical Design Data in which Mathematics has been confined to Simple Algebra: Part II—High-Frequency Compensation].—E. A. Henry. (*QST*, April 1945, Vol. 29, No. 4, p. 11. May 1945, No. 5, pp. 32–38.)

2599. Discussion on "Design of Broadcast and Television Receivers for the Post-War Market."—I.E.E. Radio Section. (*Wireless World*, June 1945, Vol. 51, No. 6, pp. 174–175.) Summary of opening paper (L. H. Bedford) and subsequent Discussion: *see* also 2194 of July.

2600. Ultra-High-Frequency Converter Analysis.—H. Stockman. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 140–143.)

"Methods of analysing mixer circuits are reviewed. Mathematical analysis of converters is abandoned in favour of conversion diagrams [Chaffee: *cf.* Stockman, 777/8 & 804, 820 of March] from which u.h.f. converter characteristics can be studied. Diode and crystal conversion diagrams illustrate the method."

2601. Crystal-Type Frequency Converter [Graph & Caption only].—Anon. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, p. 214.)

"The non-linear E/I characteristics of certain crystals have long been used for modulation and demodulation. The accompanying graph serves as a convenient calculator for operation of these crystals as a frequency converter . . ."

2602. Fading Effects at High Frequencies.—J. B. Moore. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 100–109.)

Commercial communication services operating between 4 and 24 Mc/s are adversely affected by field-strength variations of less than one minute duration. Automatic gain control to take care of general fading of the slower type is usually used in combination with other methods which include: frequency diversity; space diversity; polarisation diversity; ray selection and diversity; limiting; frequency and phase modulation; exalted-carrier receivers, and single-side-band. No one method constitutes a complete solution to the problems of fading, and different combinations of the basic methods must be used for different types of service. Another line of attack on the problem is the development of a code or system of communication which will tolerate malformation of the signal without causing an incorrect letter or character to be recorded on the received copy.

2603. The See-Saw Circuit: a Self-Balancing Phase-Splitter.—M. G. Scroggie: Philips Company. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 194–196.)

The Philips phase-splitter circuit (1485 of May) "is an interesting alternative to the several better-known types; but as the primary purpose of the diagram was to illustrate some notes on new Dutch valves . . . the layout tended to obscure the basic principle of the phase-splitter. It may therefore be helpful to re-draw the circuit in its simplest form . . ." This "see-saw" circuit is compared with the paraphase system, and the special merit of the former—its self-balancing properties—is brought out.

2604. Exalted Carrier Reception.—M. G. Crosby. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 296..302: Report of I.R.E. 1945 Winter Technical Meeting.)

The elimination of distortion is accomplished by filtering the carrier and recombining it with the signal at a raised or exalted level, or by recombining it in a type of detector which inherently eliminates the carrier-fading distortion.

2605. Low-Voltage Receiver [operating from 24-Volt Battery as Sole Source of Power].—L. Lorch. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 86–87 and 188, 189.)

"Successful construction of low-voltage radio equipment depends upon three factors: (i) correct choice of tubes, (ii) full utilisation of the supply voltage by proper dimensioning of all components apt to cause undesired voltage losses in plate and screen circuits, and (iii) special treatment of bias circuits in order to maintain tube uniformity." These points are considered in the receiver described, developed for an aircraft application and weighing below three pounds. Under flight conditions (battery voltage 28 V) the sensitivity is better than 5 μV for 50 mW power output (which can be increased to 600 mW): total power consumption is 20 W.

2606. Panoramic Reception [General Principles upon which the Panoramic System is based and Ways in which it may Serve the Operator of a Post-War Amateur Station].—H. Pollack. (*QST*, March 1945, Vol. 29, No. 3, p. 18.)

2607. A.G.C.-Noise Considerations in Receiver Design.—J. B. Moore. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 116–119.)

Automatic gain control is considered for com-

munications receiver service from the standpoint of its effect on signal-to-noise ratio at various signal voltages. It is shown that for small input signals, the final signal-to-noise ratio in the output of the receiver is determined by the signal-to-noise ratio existing at the input. For higher signal levels, due to the a.g.c. action, the signal-to-noise ratio at the output of the receiver is determined by the noise equivalent of the converter. To maintain the improvement in signal-to-noise ratios at the higher signal inputs it is desirable to employ high gain in the r.f. amplifier.

2608. DISCUSSION ON "ASPECTS OF INTERFERENCE SUPPRESSION UNDER POST-WAR CONDITIONS."—(*Journ. I.E.E.*, Part III, March 1945, Vol. 92, No. 17, pp. 21–22.)

In the discussion, opened by P. R. Coursey, there was virtually unanimous agreement on the necessity of some kind of legal machinery for curbing electrical interference with radio reception. Though it was generally believed that interference would increase after the war unless effective steps were taken to check it, the general opinion was that the trouble was not likely to be particularly serious at ultra-high frequencies. It was pointed out, however, that the radiation from ignition systems of motor vehicles covered a very wide frequency range. Capacitors with properties suitable for interference suppression at frequencies above 50 Mc/s would probably soon become generally available; existing designs were inadequate for this specialised purpose.

2609. SHIELDING DIELECTRIC HEATING INSTALLATIONS.—Klingaman & Williams. (*See* 2856.)

2610. DIATHERMY PROBLEMS: STUDY OF INTERFERENCE REDUCTION INDICATES THAT ADDITIONAL BAND-WIDTH ON 27 Mc/s WOULD MAKE F.C.C. ALLOCATIONS SERVICEABLE.—(*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 107–108 and 223, 224.)

2611. GENERAL NOTES ON AUTOMATIC TAPE RECORDING OF HIGH-SPEED SIGNALS.—R. B. Armstrong & F. W. J. Sainsbury. (*Marconi Review*, April/June 1945, Vol. 8, No. 2, pp. 46–59.)

Authors' summary:—"The recording of high speed morse signals requires equipment having certain well defined characteristics. These notes are intended for the use of operating and other staff handling such equipment for the first time. They cover a general review of the nature of the problems involved rather than detailed operating instructions." The article describes the mode of operation of the "undulator," this being the instrument in general use for obtaining ink records of morse characters.

AERIALS AND AERIAL SYSTEMS

2612. POLAR DIAGRAMS: EXPERIMENTS WITH A HALF-WAVELENGTH RECEIVING AERIAL AND A V-TYPE WIRE-NETTING REFLECTOR.—J. S. McPetrie, L. H. Ford & J. A. Saxton. (*Wireless Engineer*, June 1945 Vol. 22, No. 261, pp. 263–268.)

Author's summary:—"Experimental measurements have been made of the polar radiation diagram of a receiving system comprising a half-wavelength aerial associated with a V-type reflector, used on a wavelength of 50 cm. The reflector consisted of two screens of galvanised iron wire netting of ½ inch mesh; polar diagrams were measured for various angles of the V between 80° and 330° and distances of the aerial of quarter, half and three-quarter wavelengths from the apex of the reflector. Gains up to 13 decibels over a half-wavelength dipole were obtained with this simple aerial system.

"Experiments using a half-wave dipole aerial in the place of a flat sheet reflector corresponding to a V-type reflector of 360° are also described. The results show that in this case a polar diagram having almost uniform sensitivity over an arc of 180° can be obtained combined with a single minimum in the direction of the transmitter. Such a system may be of use for direction-finding purposes."

2613. A SQUARE-LOOP F-M ANTENNA [Theory, Constructional Details and Tuning Procedure].—J. P. Taylor. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 96–100.)

"The six-layer square-loop antenna now in use at f-m station WBAL, Baton Rouge, Louisiana, is of considerable interest because of its high gain . . . and, particularly, because it is built around the top of the tower rather than on an extension."

2614. WABC'S NEW TWO-BAY ANTENNA [for F.M. Transmissions: provides "Considerably Improved Service in Metropolitan & Suburban Areas": 847 ft. Height].—O. Prestholdt. (*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 88–89 and 152, 156.]

2615. EASING MULTI-PATH PROBLEMS [in Television Transmission: the Possibilities of High Towers, such as the 2500 ft. Tower designed for New York's World's Fair, 1939].—(*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 95 and 140.)

2616. NEW TYPES OF RADIATORS.—A. G. Kandoian. (*Electronics*, March 1945, Vol. 18, No. 3, p. 312; Report of I.R.E. 1945 Winter Technical Meeting.)

New types of antenna are described having a radiation pattern essentially equivalent to that of a dipole. Three types are described. One gives vertical polarization with an omnidirectional horizontal pattern. The second is a loop antenna with an omnidirectional pattern in its own plane. The third also consists of a loop and perpendicular to it is mounted a vertical dipole. The radiation pattern of this antenna is similar to the other types but the free-space field at all points has both horizontal and vertical components in equal amounts. Any desired ratio of amplitude as well as phase relationship between the two component fields may be obtained.

2617. POLYPHASE SYSTEMS APPLIED TO R.F. [Several Simple Applications of Multiphase Excitation: Automatic Tuning of an Amplifier: Rotation of an Antenna Pattern].—R. V. Bickmore. (*QST*, March 1945, Vol. 29, No. 3, p. 11.)

2618. ON THE EXCITATION OF VIBRATORS IN ANTENNAS.—M. Leontovich & M. Levin.

(*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 384; in English, summary only; in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

"A general method is proposed for solving the problem of distribution of a current in a thin conductor-vibrator of a rectilinear as well as of a curvilinear shape, the acting electromotive forces being specified. In solving the problem repeated recourse is made to the circumstance that the radius of the cross-section is much less than the wavelength. The problem is finally reduced to the solution of an integro-differential equation which is true for finite conductors. The results of the calculations clear up the fundamental problems which arise here: the problem of antenna feed (input resistances), the interaction of various parts of the antenna (induced resistances), tuning of the antenna."

2619. TRANSPORT-AIRCRAFT ANTENNA CHARACTERISTICS [Method of Measuring the Characteristics of Aircraft Antennas with a Q-Meter and Results of Measurements on Several Types of Aircraft].—E. F. Kiernan. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 126–127.)

2620. AUTOMATIC ANTENNA SWITCHING [Simplified System for Instantaneous Selection from a a Number of Units].—A. K. Robinson. (*QST*, April 1945, Vol. 29, No. 4, p. 38.)

2621. PLYWOOD ANTENNA MASTS [Light-weight Tubular Masts for Mobile Equipment].—"W. E. B." (*QST*, May 1945, Vol. 29, No. 5, p. 27.)

2622. PLANES DELIVER PLYWOOD RADIO MASTS [first used in African Campaign].—(*Electronics*, July 1944, Vol. 17, p. 150.)

VALVES AND THERMIONICS

2623. KLYSTRON CHARACTERISTICS [Application of Dynamic Methods to Measurement of Klystron Characteristics].—C. Dodd. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 250...262: Report of I.R.E. 1945 Winter Technical Meeting.)

2624. TWO-RESONATOR KLYSTRON OSCILLATOR [Dependence of Power Output of Klystron Oscillators on Beam Transconductance].—D. R. Hamilton. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 262, 266: Report of I.R.E. 1945 Winter Technical Meeting.)

2625. KLYSTRON OSCILLATORS.—A. E. Harrison. (*Electronics*, Nov. 1944, Vol. 17, No. 11, pp. 100–107.)

The operation of velocity-modulation oscillators is explained by correlating the theory of electron bunching with the performance of two coupled circuits. The effects of resonator tuning, feedback and electrode voltages are analysed and compared with the experimental results obtained.

2626. MEASURING KLYSTRON AMPLIFIER FEATURES [by Oscillographic Testing Methods].—C. Dodd. (*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 76–79.) From the Sperry Gyroscope laboratories.

2627. MAGNETRON OSCILLATOR FOR V.H.F. RESEARCH [Summary of Circular].—J. T. Tykociner & L. R. Bloom. (*Electronics*, May 1944, Vol. 17, No. 5, p. 214.) *See* 2878 of 1944.

2628. ORBITAL-BEAM U.H.F. TUBES.—R. M. Smith. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 103–105.)

"Output frequencies as high as 500 Mc/s can be varied continuously or shifted back and forth between two or more values by applying appropriate keying signals to electrostatic deflecting plates, so as to vary the transit time between control grid and plate. Modulating voltages may also be applied to the deflecting plates.

2629. MINIATURE VALVES FOR BROADCAST AND TELEVISION RECEIVERS [saving 20–40% in Equipment Size: combining Special Features of Acorn Valves & Filament-Type Miniature Valves].—R. C. A. (*Science*, 2nd March 1945, Vol. 101, No. 2618, Supp. p. 10.)

2630. REPORT ON THE NOISE OF SOME RADIO TUBES WITH FLOATING GRID [Calculations & Measurements: Great Superiority of the Philips AF7: Design of Amplifier to give a High Counting Ratio for Alpha Particles].—K. J. Keller & H. J. A. Vesseur. (*Physik. Berichte*, No. 17, Vol. 24, 1943, p. 1157.) Abstract of the *Physica* paper referred to in 1589 of 1944.

2631. ELECTROMETER TUBE [Minute Measurements with Electrometer Tube having Functions of Grid and Plate Reversed: Sensitivity made Possible by Extremely Low Grid Current and High Grid-to-Cathode Resistance].—W. A. Hayes. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 282, 284: Report of I.R.E. 1945 Winter Technical Meeting).

2632. INVERTED TRIODE FOR INDUSTRIAL MEASUREMENTS.—(*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 176–192.)

Measurement of currents of the order of 10^{-14} ampere required in many physical and chemical problems can now be carried out with the aid of a new electronic tube. In this tube the normal functions of the anode and grid are interchanged, enabling bias to be applied which reduces to zero the current to the electrode used as the control grid. Precautions are required to minimise surface leakage between the various electrodes.

2633. FRACTIONAL-MU TRIODE [used for High-Voltage Supply for C.R. Tube].—R. C. Hergenrother & R. L. Freeman. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 286..292: Report of I.R.E. 1945 Winter Technical Meeting.) Referred to in 2745, below.

2634. EXTERNAL ANODE TRIODES: CHARACTERISTICS AND APPLICATIONS [Part II (of a Four-Part paper): Consideration of Cooling: Flash-Arcs and Secondary Emission in Design].—A. J. Ebel. (*Communications*, Feb. 1945, Vol. 25, No. 2, pp. 70..77 and 106..110.) For Part I *see* 2228 of July.

2635. Space-Charge Effects between a Positive Grid and Anode of a Beam Tetrode [Part III: Continued from issue for May 1945: the Effects on the Characteristic Curve of Beam Spread due to Electron Mutual Repulsion and of Secondary Emission].—G. B. Walker. (*Wireless Engineer*, June 1945, Vol. 22, No. 261, pp. 276–281.)

2636. Evaluating Direct Current in Triodes. —G. A. Grünberg. (*Journ. of Phys.* [of USSR], No. 6, Vol. 7, 1943: long summary in *Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 106 and 192..195.)

"A method is developed for the approximate calculation of the electron current through a cylindrical triode in the presence of a current-limiting space charge between cathode and grid. The computations are based on Langmuir's relation for a cylindrical, space-charge-limited diode. . . . In the article an expression for an equivalent voltage E' is derived which, when inserted in the above formula, gives the direct current in a space-charge-limited triode . . ." E' is also found for the case of a plane space-charge-limited triode.

2637. Supply-Voltage Effect on Transitron Performance.—C. Brunetti. (*Communications*, Feb. 1945, Vol. 25, No. 2, pp. 60–64.)

2638. R.F. Pentodes as Transitron Oscillators [Need for Standardisation of Valve Parameters which yield the Negative Resistance Characteristic employed in the Transitron Oscillator].—E. Kohler. (*Communications*, Feb. 1945, Vol. 25, No. 2, pp. 64 & 78.)

2639. Equivalent Plate-Circuit Theorem [Continuation of Correspondence: *See* 3169 of 1944].—H. Stockman. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, p. 344.)

2640. Equivalent Triode Networks [Four-Terminal Networks equivalent to Various Triode Connections].—H. A. Wheeler. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 304, 306, 308: Report of I.R.E. 1945 Winter Technical Meeting.)

2641. The Phase Convention of Currents and Voltages in Valve Circuits [Discussion of Equivalent Valve Circuit and the Sign Convention for the Anode Generator: arising from Article by K. R. Sturley in *Wireless Engineer*, May 1945].—G. W. O. H. (*Wireless Engineer*, June 1945, Vol. 22, No. 261, pp. 261–263.

2642. An Investigation of Short-Time Thermionic Emission from Oxide-Coated Cathodes—R. L. Sproull. (*Phys. Review*, 1st/15th March 1945, Vol. 67, No. 5/, pp. 166–179.)

Author's summary:—Vacuum-tube circuits were developed to measure thermionic current as a function of time for times ranging from 0.2 to 300 microsec. The decay with time of the temperature-saturated electron emission from oxide-coated cathodes was observed with this apparatus. Simultaneously with the application of anode voltage to an experimental diode the thermionic current density rose to an initial value and subsequently decayed to a steady value 1/5 to 1/15 of the initial value. The rate of decay was proportional to the current density, the decay requiring about 20 μsec. at 1200° K and about 500 μsec. at 900°K. The initial current exhibited a somewhat greater anode-voltage effect than did the steady state current. The range of decay was independent of the thickness of cathode coating over the region 1 to 30 mg. of oxide per sq. cm. An electrolytic conduction hypothesis of the decay process is proposed. The form of the observed current as a function of time agreed with the form predicted by this theory. The observed rate of decay as interpreted on the basis of the electrolytic conduction hypothesis indicated that within a single crystal of barium or strontium oxide between 0.05 and 0.5 of the total conduction current is ionic. The possible connection of this decay with the "flicker effect" is noted.

2643. The Secondary-Electron Emission of the Alloys of Nickel and Beryllium: *also* Researches on the Secondary-Electron Emission of Certain Alloys: *and* Some Researches on the Industrial Application of Alloys with High Secondary Emission.—G. Gille: I. Matthes: H. Raudembusch. (*Zeitschr. f. tech. Phys.*, Sept. 1941, Vol. 22, No. 9, p. 228 onwards: p. 232 onwards: p. 237 onwards.)

Summaries of these three papers are given in *Rassegna d. Stampa Tecnica Tedesca* [Rome], Nov./Dec. 1941, Electrotechnics Section, pp. 396, 395 & 394. They deal with Be–Ni, Cu–Ni, and Be–Cu alloys as possible substitutes, for s.e. electrodes, of the alkali metals, which are difficult to prepare and fragile. Special attention is given to the improvement of the s.e. factor by thermal treatment, thermal treatment with introduction of air at various pressures, exposure to electrical discharge in a gaseous atmosphere, and alternations of the thermal and electrical treatments. Factors up to 12.2 have been obtained (p. 395).

2644. On the Velocity Distribution of the Electrons in Field Emission.—E. W. Müller. (*Zeitschr. f. Phys.*, No. 5/6, Vol. 120, 1943, p. 261 onwards: short summary in *Physik. Berichte*, No. 16, Vol. 24, 1943, p. 1098.)

From the Stabilovolt laboratories. "The wave-mechanical theory of field emission is far-reachingly checked by new investigations. As regards the dependence of current density on field strength good agreement was found, while as regards the velocity distribution of the field electrons there was a serious discrepancy. The writer calculates the velocity distribution according to the tunnel-effect concepts. The experimental arrangements for measuring the velocity distribution are subjected to a critical examination with respect to their sources of error. Using the counter-potential method—with exclusion of known sources of error—the velocity distribution in the case of a tungsten cathode is determined experimentally. Complete agreement with the calculated curve is obtained. The velocity distribution is the same for the emission from different crystal directions." For Richter's work on the subject *see* 445 of 1943.

2645. Essay in Radio-Frequency Heating.—T. C. Macnamara & H. T. Greatorex. (*Wireless Engineer*, June 1945, Vol. 22, No. 261, pp. 269–275.)

Describes an eddy-current heating apparatus for flashing a getter in a small neon tube. The frequency of operation was arbitrarily chosen as 0.5 Mc/s, and the final arrangement consisted of a 300-watt generator feeding a 10-turn heating coil of copper strip. Flashing occurred in about 2 seconds. Interference was made negligible by careful screening and by filtering of leads.

2646. Automatic Machine Finds Bent Valve-Pins [Bent or Burred Pins separated out by Vibration Table].—Fraser & Chalmers, Ltd. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 286, 288.)

2647. Quality Control in Tube Manufacture.—E. Goddess. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 122–125.)

Author's summary.—"A discussion of the problems involved in setting up a statistical method of controlling the quality of electronic tubes and component parts during manufacture: Instructions are given for the use of control charts in connection with random sampling techniques to detect promptly when a process is out of control."

2648. Shrinkage Analysis in Tube Manufacture [Procedure for Isolating the Factors Responsible for Rejected Tubes].— E. Goddess. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 138–141.)

2649. The Use of Glass in High-Vacuum Apparatus.—R. W. Douglas. (*Journ. of Scient. Instr.*, May 1945, Vol. 22, No. 5, pp. 81–86.)

DIRECTIONAL WIRELESS

2650. Radar Techniques [Part I—First Principles: Part II—Simple Analogies].—C. B. DeSoto. (*QST*, April 1945, Vol. 29, No. 4, p. 20: May 1945, No. 5, pp. 46–49.)

2651. Radar for Safety.—(*Science News Letter*, 31st March 1945, Vol. 47, No. 13, p. 196.)

Radar in the control room will show on a screen the position of all aircraft within a radius of 25 miles of the airport and would be particularly useful in fog. Airborne radar as a collision warning device will show the position of other aircraft and obstacles. The apparatus is developed by the Civil Aeronautics Administration in the U.S.A.

2652. Navy's Dow suggests Radar Patent Pool.—J. B. Dow. (*Electronic Industries*, March, 1945, Vol. 4, No. 3, pp. 94 and 199..202.) For a British editorial on this proposal see *Wireless World*, July 1945, Vol. 51, No. 7, p. 193.

2653. Facts and Figures on Production in the Canadian Radar and Electronics Industry.—C. D. Howe. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 260, 262.) Excerpts from speech in Canadian House of Commons.

2654. V.H.F. Homing Device: Army develops Simple System to locate Lost Planes and help Pilots Navigate Safely to their Fields.—V. Faught & E. Spears. (*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 104–105.) *See* also 1818 of June.

2655. The C.A.A. Instrument-Landing System: Part II [Details of Localized Transmitter, Monitor Units, and Receivers Used in Planes for Blind-Landing System Now Officially Adopted for Civil Aviation in America].—P. Caporale. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 128–135.) For Part I *see* 2237 of July.

2656. A.A.F. Instrument Approach System.—F. L. Moseley. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 200, 202, 206: Report of I.R.E. 1945 Winter Technical Meeting.)

"This equipment forms the system which picks up a pilot at about 15 miles distant and 3000 feet up from a landing field and turns him loose at ½ mile and 50 feet up all set for landing."

2657. Army Radio D.F. Networks.—G. Twist. (*Electronics*, November 1944, Vol. 17, No. 11, pp. 118–124.)

A description of the SCR-291 radio direction finder used by the A.A.C.S. to provide accurate bearings for military pilots on world-wide air routes: The set is of robust design and is made by the Federal Telephone and Radio Corporation. It is semi-portable and employs a U-Adcock antenna designed for fixed station use. A cathode-ray tube and a motor-driven goniometer provide instantaneous bearings with a minimum of the operator's time and attention. The equipment is continuously variable over a frequency range of 2 to 10 Mc/s, while its average sensitivity is between 5 and 15 microvolts per metre for a $\pm 2°$ bearing accuracy.

2658. Synthetic Training for Aircrews: Aerial Navigation by Wireless practised on the Ground by Artificial Aids.—Rediffusion, Ltd. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 205–207.)

2659. The Compensated-Loop Direction Finder—F. E. Terman & J. M. Pettitt. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, pp 307–318.)

Shows how, for numerous applications, this type of instrument may be designed to provide almost complete neutralization of the pick-up due to unwanted field components for a wide range of operating conditions. At shorter wavelengths the frequency coverage is reduced and neutralization is not so efficient.

ACOUSTICS AND AUDIO-FREQUENCIES

2660. Visualising Centimetric Waves [and the Behaviour of Wave-Guides & Horns].—Bacon. (*See* 2507.)

2661. Frequency-Modulation Phonograph Pick-up.—B. F. Miessner. (*Electronics*, Nov. 1944, Vol. 17, No. 11, pp. 132–133.)

Description of a phonograph pick-up having a flat frequency-characteristic over the audio range, with self-contained volume expansion and less than one ounce needle weight. The needle varies the

capacitance in the tuned circuit of an oscillator, thus causing frequency modulation.

2662. TRACKING ANGLE IN PHONOGRAPH PICKUPS [Distortion Due to Tracking Error Minimized by Bending Pick-up Arm and Overhanging Needle: Equations developed for Determining Optimum Bending and Overhang for Any Given Conditions].—B. B. Bauer. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 110–115.)

2663. A WAR CORRESPONDENT'S RECORDER AT B.B.C. [Simplified Lightweight Disc-Type Recording Unit for Front-Line Reporting].—W. J. Lloyd & D. E. L. Shorter. (*Communications*, Feg. 1945, Vol. 25, No. 2, pp. 33–35 and 68–69.)

2664. A NEW MAGNETIC PROCESS FOR SOUND RECORDING [Film with Acetyl Cellulose Base incorporating a Magnetic Material: Advantages over Photographic Film].—German Broadcasting Company & A.E.G. (Summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], Nov./Dec. 1941, Optical Section p. 60.)

2665. NOTES ON DISTORTION IN PHONOGRAPH REPRODUCTION CAUSED BY NEEDLE WEAR [Analytical Discussion & Some Measurements].—B. B. Bauer. (*Journ. Acous. Soc. Am.*, April 1945, Vol. 16, No. 4, pp. 246–254.)

2666. GRAMPHONE RECORDS: CONDITIONS FOR OBTAINING MAXIMUM PLAYING TIME.—S. Macklem. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 359, 360, & 366.)

From Research Enterprises, Ltd. "The maximum playing time of a disc record is realised when the recorded surface extends from the outside of the record to half-way towards the centre and no further. To carry the recording beyond this point represents a loss of fidelity or a waste of possible recording time . . ." A formula is given for choosing the turntable speed. On these principles the writer finds he can put about eight minutes playing onto a cheap 10-inch disc "without serious loss."

2667. ELECTRICAL AIDS TO PUBLIC SPEAKING [Informal I.E.E. Discussion: Replacement of Conspicuous Array of Microphones by Small Microphones: Masking of Higher Frequencies by the Amplified Lower Frequencies: etc.].—P. G. A. H. Voigt & others. (*Electrician*, 11th May 1945, Vol. 134, No. 3493, p. 428: *Wireless World*, July 1945, Vol. 51, No. 7, p. 201.)

2668. PIEZOELECTRIO TEXTURES [including the Preparation of Rochelle-Salt Plates].—Schubnikov. (*See* 2710.)

2669. DESIGN OF ELECTRONIC MEGAPHONE.—R. C. A. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 200..209.)

2670. ACOUSTIC INTENSITY DISTRIBUTION FROM A PISTON SOURCE [Mathematical Analysis with Experimental Confirmation].—A. O. Williams, Jr., & L. W. Labaw. (*Journ. Acous. Soc. Am.*, April 1945, Vol. 16, No. 4, pp. 231–236.)

2671. FREQUENCY-RESPONSE CURVE TRACER [Laboratory Unit Capable of Drawing Directly Frequency-Response Curves of Microphones and Loudspeakers].—H. B. Shaper. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 118–121.)

2672. AUDIBLE AUDIO DISTORTION [Stressing the Need for the Suppression of Intermodulation Frequencies].—H. H. Scott. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 126–131.)

2673. DISTORTION IN AUDIO-FREQUENCY TRANSFORMERS: TESTING CORE MATERIALS AT LOW SIGNAL LEVELS.—T. Roddam. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 202–203.)

"Two conclusions can be drawn from the results described. The first is that an investigation of the detailed behaviour of iron alloys as transformer cores is needed. The second is that the transformer designer must, when using an unfamiliar material, examine not only the non-linearity coefficient but also the law which his material follows."

2674. "SOUND INSULATION AND ACOUSTICS" [Book Review].—Acoustics Committee of Building Research Board of Dept. of Sci. & Ind. Res. (*Proc. Phys. Soc.*, May 1945, Vol. 57, No. 321, p. 258.)

2675. FORM OF THE SURROUNDINGS AND REVERBERATION TIME IN HALLS FOR THE PROJECTION OF SOUND FILMS.—E. Kammerer. (*Kinotechnik*, May 1942: illustrated summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], Sept./Oct. 1942, Optical Section pp. 33–34.)

2676. SOUND ABSORPTION CHARACTERISTICS OF INDIAN MATERIALS: Part I.—S. Chatterjee. (*Indian Journ. of Phys.*, June 1944, Vol. 18, No. 3, pp. 135–143.)

2677. ATTENUATION OF SOUND IN LINED CIRCULAR DUCTS [Tables and Graphs].—C. T. Molloy & R. Honigman. (*Journ. Acous. Soc. Am.*, April 1945, Vol. 16, No. 4, pp. 267–272.)

2678. SOUND PSYCHOLOGY [Summary of S.M.P.E. Paper on the Control of Sound and Its Psychological & Physiological Effects: Five Methods of controlling Sound in order to get the Most from It].—H. Burris-Meyer. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 244..248.) For previous work by this writer *see* 128 of 1942, 3063 of 1943, & 1235 of 1944.

2679. CERTAIN APPLICATIONS OF PHYSICAL PRINCIPLES TO THE PLAYING OF MUSICAL INSTRUMENTS [Touch in Piano Playing: No Detectable Difference in Single Note Struck by Human or Mechanical Agency].—W. F. G. Swann. (*Journ. Franklin Inst.*, March 1945, Vol. 239, No. 3, pp. 163–184.)

2680. ARGUMENT FOR ELECTRONIC MUSIC [Facility offered, for the First Time, for Key Changes

which will be Strictly Harmonious on an Instrument tuned in the Just Scale: Application to Hammond Organ and Novachord].—S. T. Fisher. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 214..244.)

Helmholtz in 1860 pointed out the serious defects of the Tempered Scale (hitherto the only practical one) and suggested that in a generation or two it might have a very marked effect on our acuteness of appreciation for harmony. "It appears that his predictions have been fulfilled to a large extent and that the return of a strict perception of harmony is only possible by replacing the Tempered Scale with the Just Scale . . ."

2681. Measuring Distance with Reflected Sound Waves [Instrument giving Direct Continuous Indication of Distance or Depth]. E. Norrman. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 198..216.)

2682. Curved Quartz Crystals as Supersonic Generators [Greater Excess-Pressure Amplitude Close to Generator obtainable from Curved Crystal than from Similar Flat Crystal].—L. W. Labaw. (*Journ. Acous. Soc. Am.*, April 1945, Vol. 16, No. 4, pp. 237–246.)

2683. An Extended-Range Audio Oscillator [An *R-C* Oscillator, Range 16 c/s to 85 000 c/s].—C. J. Leipert. (*QST*, Feb. 1945, Vol. 29, No. 2, p. 24.)

2684. High- and Low-Pass Filter Design [Elimination of Much of the Arithmetical Drudgery by use of Reactance Slide-Rule].—C. J. Merchant. (*Electronics*, Feb. 1945, Vol. 18, No. 2, p. 144.)

PHOTOTELEGRAPHY AND TELEVISION

2685. Discussion on "Design of Broadcast and Television Receivers for the Post-War Market."—I.E.E. Radio Section. (*Wireless World*, June 1945, Vol. 51, No. 6, pp. 174–175.) Summary of opening paper (L. H. Bedford) and subsequent Discussion: *see* also 2194 of July.

2686. New Television Receiver shows Brighter Pictures [and Five Times Larger than on Pre-War Sets: "Improved High-Voltage Projection Tube, Unique High-Efficiency Optical System (Concave Mirror & Plastic Lens), Plastic Screen, & Automatic Frequency Control"].—C. B. Jolliffe. (*Sci. News Letter*, 24th March 1945, Vol. 47, No. 12, p. 184.)

2687. Engineering Aspects of Television Programming [Up to Thirty Fixed-Position Television Cameras per Studio Considered Essential to Provide Frequent Viewpoint Changes Comparable with Cinema Films].—V. M. Bradley. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 107–109.)

2688. Television Relays.—Fancher. (*See* 2801.)

2689. Reflective Optics in Projection Television [Methods of Projecting Television Pictures by the Uses of Aspherical Correcting Lenses moulded from Clear Plastics].—I. G. Maloff & D. W. Epstein. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 92–97.)

2690. Projection Systems for Theatre Television [Supersonic Diffraction Valve: Skiatron].—(*Electronics*, May 1945, Vol. 18, No. 5, pp. 218..230.)

2691. Spatial Impression of a Plane Image by Monocular Observation [Binocular Vision Not Essential to Stereoscopic Effect: if Developed Practically, would provide Better Solution of the Stereoscopic Cinema Problem].—G. Kogel. (*Photographische Korrespondenz*, April/June 1941: short summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], Jan./Feb. 1942, Optical Section pp. 7–8.)

2692. A New French Method for Stereoscopic Cinema Projection [the "Cyclostereoscope" with Rotating Drum synchronised with the Film].—F. Savoy. (*Die Photographische Industrie*, 17th Feb. 1942: short summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], March/April 1942, Optical Section p. 15.)

2693. Television Service hinges on Frequency [Extracts from Testimony before Public Hearing conducted by F.C.C.].—E. W. Engstrom. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 102–104 and 170..177.) *See* also 2260 of July.

2694. Easing Multi-Path Problems [in Television Transmission].—(*See* 2615, above.)

2695. On the Technique of the Electrical "Storage" of Images.—G. Krawinkel & H. Bödeker. (*T.F.T.*, Feb. 1940, Vol. 29, No. 2, p. 37 onwards.) For a long summary see *Rassegna d. Stampa Tecnica Tedesca* [Rome], March/April 1940, Electrotechnics Section pp. 122–124.

2696. Power Supplies for Photoelectric Controls [to avoid Troubles due to Undesired Modulation of the Light Source by the Mains Frequency, and to Mains Voltage Fluctuations].—D. Schulman. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 177..196.)

2697. Facsimile Equipment Communication Units: Picture and Printing Transmission and Reception Components in use by Signal Corps for Radio and Wire Lines.—R. C. Davies & P. Lesser. (*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 96–99 and 170.)

MEASUREMENTS AND STANDARDS

2698. Stable V.H.F. Oscillators: Design of a Tunable-Line Oscillator for 280–450 Mc/s [for Laboratory Use].—Solley. (*See* 2577.)

2699. V.H.F. Dummy Antenna.—S. Cutler. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 129–131.)

For frequencies around 100 Mc/s: it consists of a tubular resistor of 70 ohms, with its reactance

cancelled by connecting a suitable *L–C* series combination across it. A thermocouple " wattmeter " is built in to the assembly.

2700. F.M. Field Survey Techniques.—P. B. Laeser. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 110–115).

Detailed description of the procedure used to secure data for plotting actual coverage contours of an F.M. station, as required by the F.C.C., one year after it first goes on the air.

" A field intensity meter was designed for measuring field intensities of stations operating in the high-frequency spectrum, for the purpose of checking antenna efficiency, service area, and carrying out research on propagation. The instrument covers the band 20 to 25 Mc/s and has a range of 10 to 500 000 microvolts."

2701. R.F. Spectrum Analysers [Properties of Tuned Circuits in Terms of the Relations between Bandwidth, Resolving Power and Repetition Rate].—E. Williams. (*Electronics*, March 1945, Vol. 18, No. 3, p. 286: Report of I.R.E. 1945 Winter Technical Meeting.)

2702. The Foundations of Electrical Measurement.—L. Hartshorn. (*Journ. I.E.E.*, Part I, Oct. 1944, Vol. 91, No. 46, pp. 377–381.) A summary was dealt with in 2663 of 1944.

2703. Standard-Frequency Broadcast Service of National Bureau of Standards.—(*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, p. 334.) A revision of the programme detailed in 3922 of 1944. Standard radio frequencies are provided at 2.5, 5, 10 and 15 Mc/s, giving a 24 hour service. Three channels are used simultaneously. Carriers are modulated at 440 and/or 4000 c/s, continuously together with pips, each 5 milliseconds long, transmitted each second. Transmitted accuracy better than 1 part in 10^7, for carriers and modulation.

2704. Standard - Frequency Transmissions [Schedule of B.B.C. Transmissions on 200, 6180, 9510 and 17 810 kc/s].—(*Wireless Engineer*, June 1945, Vol. 22, No. 261, p. 282.)

2705. Frequency Monitor Stroboscope.—W. S. Wiggins & S. G. Guenther. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 138–139.)

Frequency-difference pulses from a Western Electric 1-C Frequency Monitor are amplified and light a 2-watt neon lamp which illuminates a suitable rotating stroboscope disc. This simplifies frequency-checking operation and gives accuracy of a tenth of a cycle.

2706. Frequency Meter for Use by Factory Personnel [Range 10 c/s to 50 kc/s: Linear Direct Reading Dial: Accuracy about 2%].—W. R. Strauss. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 150, 152, 154.)

2707. Frequency-Response Curve Tracer [Laboratory Unit Capable of Drawing Directly Frequency-Response Curves of Microphones and Loudspeakers].—H. B. Shaper. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 118–121.)

2708. The Accuracy of Reception of Some Short-Wave Time Signals [and Its Decrease with Increasing Distance].—W. Uhink & A. J. Corpaciu. (*Physik. Berichte*, No. 2/3, Vol. 25, 1944, p. 58.) Abstract of a Roumanian paper.

2709. Quartz Blanks Multiplied by Division [Reduction in Size has Resulted in Production of More Plates per Pound of Raw Material, and also in Use of Quartz of Size and Quality Formerly Considered Non-Adaptable].—(*Electronics*, March 1945, Vol. 18, No. 3, p. 196.)

2710. Piezoelectric Textures.—A. V. Schubnikov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 20th Nov. 1944, Vol. 45, No. 5, pp. 181–183: in English.)

While applying Voigt's theory to anisotropic non-single-crystal media, the author showed that of the three possible types of media in which piezoelectric phenomena could exist one was characterised by the symmetry ∞:2 (one infinite axis and a set of transverse double axes). This type has no polar directions but it is pointed out that, contrary to general belief, whether piezoelectric phenomena may or may not take place is not decided by the presence or absence of polar directions, but rather depends upon the absence or presence of a centre of symmetry. This conclusion suggests the possibility of obtaining non-polar piezoelectrics, using mechanical means of orientating textural elements. Rochelle-salt plates were prepared by applying the melted salts to a surface by means of a brush. The resultant textures displayed considerable piezoelectric effect in response to the application of mechanical stresses. It was found that after preparation the texture must be allowed to " ripen " if the full effect is to be obtained. The author has shown that plywood has the properties of a piezoelectric texture.

2711. Piezoelectric Constants of Crystals: Group-Theoretical Treatment.—B. D. Saksena. (*Indian Journ. of Phys.*, June 1944, Vol. 18, No. 3, pp. 177–181.)

" The number of piezoelectric moduli and the relations between them have been obtained by using group-theoretical method. The results are in agreement with those given by Voigt."

2712. Ageing of Quartz Plates.—V. E. Bottom. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 206, 210: Report of I.R.E. 1945 Winter Technical Meeting.)

Etching of crystals in the final stage of manufacture has resulted in better quality crystals for operation above 6 Mc/s, along with faster and cheaper production. Investigation of the causes of changes in activity and frequency with crystal ageing has shown that etched crystals in watertight holders do not have these objectionable features.

2713. Crystal Quality.—I. F. Fair. (*Electronics*, March 1945, Vol. 18, No. 3, pp.

292, 294: Report of I.R.E. 1945 Winter Technical Meeting.)

Factors determining the performance of crystals are discussed and a figure of merit, M, for expressing quality, and a performance index, PI, suggested. The performance index is a term to express crystal performance, not in terms of the grid current of some particular oscillator, but in a fundamental circuital unit-impedance. It is a term which may be used to compare performances of crystals at different frequencies.

2714. Wire-Supported Crystals [Disadvantages of Older Systems of Mounting: Description and Advantages of Crystal Unit mounted in Evacuated Envelope, and supported by Wires connected to Silver deposited on Crystal Faces.]—A. W. Ziegler. (*Bell Lab. Record*, April 1945, Vol. 23, No. 4, pp. 140–144.)

2715. X-Ray Irradiation of Quartz Crystals. C. Roddy. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 270..276: Report of I.R.E. 1945 Winter Technical Meeting.)

In general the frequency of oscillation decreases continuously during irradiation to a limiting value, and types of plates dependent on different elastic constants are affected unequally. The technique is now being used in the production of quartz plates and rates of frequency change now being accomplished average about 40 cycles per minute of exposure to the rays.

2716. X-Ray Adjustment of Quartz Plates ["Alteration of Atomic Structure of Piezo Crystals by Irradiation accurately changes Oscillating Frequency"].—C. Frondel. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 98–100 and 166..170.) *See* also 1877 of June and back references.

2717. Equipment for X-Raying Quartz Plates.—C. Frondel. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 270, 274, 276: Report of I.R.E. 1945 Winter Technical Meeting.)

Description of preliminary experiments which consisted mainly of irradiating many crystals with various types of X-ray tubes commercially available in order to determine empirically the most appropriate conditions of irradiation.

2718. X-Rays Alter Wavelength [Use of X-Ray Irradiation to Regulate the Properties of Crystals, in particular the Frequency of Quartz Crystals used in Radio].—(*Sci. News Letter*, 21st April 1945, Vol. 47, No. 16, p. 242.)

2719. Quartz Etching Technique [Final Adjustment of Quartz Crystals by Etching Eliminates "Ageing"].—L. A. Elbl. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 120–121.)

2720. Multiple X-Y Recorder for Testing Quartz Crystals.—G. Keinath. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 106–111.)

The instrument records automatically the variations in the activity and frequency of quartz crystals over a wide range of temperature. Sixty or more crystals are placed in a chamber which is cooled to about −50° C. The temperature of the chamber is then raised slowly by a current of warm air and the records are taken during the warming-up period. The maximum temperature is from 80° C to 90° C depending on the type of crystal. The frequency of the quartz oscillator is measured by a beat method and the grid current of the oscillator is taken as a measure of the activity of the crystal.

2721. Recording Two Variables: Multiple Recorder [incorporating New "Sweep-Balance" Principle], developed for Simultaneous Measurement of Quartz-Crystal Characteristics, has Many Uses in Industry.—R. K. Hellman, with G. Keinath. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 76–78 and 158..164.)

2722. "Radio Frequency Bridges."—H. L. Kirke. (*Journ. I.E.E.*, Part III, March, 1945, Vol. 92, No. 17, pp. 2–7.)

In his Chairman's Address to the Radio Section the author describes five types of radio frequency bridge and a low-frequency capacitance bridge. Circuit diagrams and brief general descriptions of the following bridges are given. (a) Short Wave Admittance Bridge. (b) Medium and Long-Wave Admittance Bridge. (c) Medium and Long-Wave Multi-Ratio Admittance Bridge. Frequency range 15 kc/s to 2 Mc/s, capacitance range 0.01 $\mu\mu$F to 25,000 $\mu\mu$F, resistance range 10 ohms to 10 megohms. (d) Ultra-Short-Wave High-Admittance Bridge. Frequency range 100 kc/s to 100 Mc/s. (e) Medium and Long-Wave Series Low-Impedance Bridge. Developed primarily for the measurement of inductance at medium frequencies (100 kc/s—2 Mc/s) and particularly for low values of inductance. (f) Audio-Frequency Capacitance Bridge. A useful bridge for the measurement of capacitances from 0.001 to 15 000 $\mu\mu$F.

2723. A General-Purpose Impedance Bridge [Simplified Switching Circuit for Resistance, Capacitance and Inductance measurement at 1000 c/s with an Accuracy of Order of 2%].—P. M. Honnell. (*Communications*, Feb. 1945, Vol. 25, No. 2, pp. 36..42 and 81..103.)

2724. Supplementary Notes on "Inductance Bridge for Communication Circuits [3562 of 1944.]—E. Mittelman. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 366, 368.)

2725. Measurement of Filter Chokes [Method overcoming Problem of the Superposed D.C. and enabling Inductance to be measured with a High A.C. Component: particularly suitable for Iron-Core Reactors used in First Section of Smoothing Filters].—L. R. Malling. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 184..192.)

2726. Transport-Aircraft Antenna Characteristics [Method of Measuring the characteristics of Aircraft Antennas with a Q-meter and Results of Measurements on Several Types of Aircraft].—E. F. Kiernan. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 126–127.)

2727. CIRCUIT-CONSTANT CHECKER [Measurements of Resonant Frequency, Inductance, Capacitance, and Q by a Portable Instrument in Frequency Range 90 kc/s to 25 Mc/s.].—G. Zaharis. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 118–119.)

2728. CAPACITOR MATCHING OSCILLATOR [Frequencies of Two Duplicate Oscillators compared: First Includes Standard Capacitor, Second Includes Unknown Capacitor].—H. H. Tepper. (*Electronics*, Nov. 1944, Vol. 17, No. 11, pp. 114–117.)

2729. NEW MEASURING INSTRUMENT [Electronic Operated Insulation-Resistance Test Meter: 0.3 to 50 000 Megohms in 3 ranges].—Jackson Automatic Electric Controls. (*Electrician*, 15th June, 1945, Vol. 134, No. 3498, p. 534.)

2730. INCREASING VACUUM-TUBE VOLT-OHMMETER SENSITIVITY [by using Vacuum-Tubes in all Four Arms of Bridge].—H. Glenn. (*QST*, Feb. 1945, Vol. 29, No. 2, pp. 35–38.)

2731. ELECTRONIC VOLTMETER WITH 5-MA METER [gives a D.C. Full-Scale Range of about 1 Volt and Removes Necessity for More Expensive and Less Robust Microammeter].—E. M. Yard. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 160..176.) Entirely satisfactory where an input resistance of one megohm per volt is adequate.

2732. A.C./D.C. COMPARATOR: A SIMPLE METHOD OF CALIBRATING A.C. METERS [instead of Indirect Calibration through Medium of Thermocouples & Microammeters: Method based on Temperature Dependence of Resistance of (*e.g.*) Torch Bulbs.]—W. H. Cazaly. (*Wireless World*, June 1945, Vol. 51, No. 6, pp. 162–164.)

2733. A NEW TYPE OF MAGNETOMETER (Oersted-meter) [Measures Weak Magnetic Fields: Calibrated in Millioersteds].—I. Bernstein. (*Journ. of Phys.* [of USSR], Vol. 8, No. 6, p. 383: in English, summary only: in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

2734. FLUXMETER USES LIGHT-BEAM [Principle & Design of New Fluxmeter for a Wide Variety of Magnetic Measurements].—General Electric Company. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 176, 180.)

2735. FURTHER PROGRESS IN THE CONSTRUCTION OF AUXILIARY EQUIPMENT FOR THE TESTING OF MAGNET POWDER CORES [in Mass Production].—A. E. W. Müller. (*Physik. Berichte*, No. 2/3, Vol. 25, 1944, p. 95: short summary only.)

2736. ON THE MEASUREMENT OF THE EFFECTIVE AREA OF A SEARCH COIL [Condenser Null-Method for Comparing with Coil of Calculable Area].—H. Mikhail & Y. L. Yousef. (*Proc. Phys. Soc.*, May 1945, Vol. 57, No. 321, pp. 238–241.)

2737. DISCUSSION ON "THE LAW OF THE MOVING-IRON INSTRUMENT" [1939 of 1943] AND "THEORY OF THE FORCE OR TORQUE OF SOFT-IRON ELECTRICAL INSTRUMENTS" [1940 of 1943].—G. F. Tagg: C. V. Drysdale. (*Journ. I.E.E.*, Part III, Dec. 1943, Vol. 90, No. 18, pp. 492–498.)

2738. METER AND INSTRUMENT JEWELS AND PIVOTS [a Survey of Research on behalf of the E.R.A.].—G. F. Shotter. (*Electrician*, 18th May 1945, Vol. 134, No. 3494, pp. 445–446.) Summary of paper and Discussion.

2739. ELECTROMETER TUBE [Inverted Triode].—(*See* 2632.)

2740. "A.S.T.M. STANDARDS ON ELECTRICAL INSULATING MATERIAL" [Book Review].—Am. Soc. for Testing Materials. (*Electronics*, May 1944, Vol. 17, No. 5, p. 354.)

2741. CLOUD HEIGHTS AND DENSITIES [Daytime Measurements Made Quickly and Accurately by Modulated Light and a Photoelectric Ceilometer].—P. H. Houser. (*Gen. Elec. Review*, April 1945, Vol. 48, No. 4, pp. 7–12.)

SUBSIDIARY APPARATUS AND MATERIALS

2742. PROGRESS IN ENGINEERING KNOWLEDGE DURING 1944: MATERIALS, DESIGN, APPLICATION.—P. L. Alger & J. Stokley. (*Gen. Elec. Review*, Feb. 1945, Vol. 48, No. 2, pp. 9–51: Bibliography pp. 55–61.)

2743. OSCILLOSCOPE FOR PULSE STUDIES [Wide-band Instrument incorporating a Triggered Sweep, Time Delay of the Signal, Beam Blanking during Standby, & Time-Interval Marking of the Trace].—H. Atwood & R. P. Owen. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 106–109.)

2744. R.F. SPECTRUM ANALYSERS.—Williams. (*See* 2701.)

2745. DIRECT CURRENT FROM OSCILLATOR [for Operation of C.R. Tube].—R. C. Hergenrother & A. L. Freeman. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 286..292: Report of I.R.E. 1945 Winter Technical Meeting.)

Design and construction of a fractional-mu triode and its use in an oscillator circuit for supplying direct current to a cathode-ray tube. If the tube has an amplification factor less than unity, the direct voltage developed across the grid leak greatly exceeds the magnitude of the anode supply voltage. A voltage of 6000 can be produced in this way from an anode supply of 300 volts.

2746. CATHODE-RAY NULL DETECTOR FOR WIEN BRIDGE [Accuracy of Better than 0.1% obtainable when Cathode-Ray Tube is used as Phase-Detecting Element of Wien Bridge Circuit for determining Frequency].—C. J. Markey. (*Electronics*, March 1945, Vol. 18, No. 3, p. 125.)

2747. A BALANCED AND REPEATING TIME BASE OF NOVEL AND COMPACT DESIGN.—F. O.

Mason. (*Journ. of Scient. Instr.*, May 1945, Vol. 22, No. 5, pp. 87–92.)

Author's summary—"A balanced time base using thyratrons, and capable of repeated operation at speeds up to 200 times per sec., is described. Several useful features are incorporated in the design, including sweep times varying from about 1 μsec. to 3000 μsec., sweep voltages ranging from 250 V. to over 2000 V., beam trapping and modulating voltages and provision for beam positioning on both the X and Y axes of a cathode ray oscillograph. The characteristics of the circuit used and the effect of changes in constants on the operation of the unit are also described."

2748. A Simple Electrical Time-Cycle Process Controller.—K. Hoselitz. (*Journ. of Scient. Instr.*, May 1945, Vol. 22, No. 5, p. 97.)

2749. Recording Two Variables: Multiple Recorder [incorporating New "Sweep Balance" Principle].—Hellmann, Keinath. (*See* 2721.)

2750. Computation of Electron Trajectories in Electrostatic Lenses of Rotational and Plane Symmetry [Application of Network Analysis to Specification of Cardinal Points of Electrostatic Lenses].—I. Zlotowski & A. F. Prebus. (*Phys. Review*, 1st/15th March 1945, Vol. 67, Nos. 5/6, p. 203.)

2751. The Application of Network Analysis to some Electron-Optical Problems [Correlation of the Trajectory Equation of an Electron Lens with the Differential Equation describing the Dependence of the Voltage Distribution upon the Impedance Characteristics of a Simple Type of Ideal Inhomogeneous Transmission Line].—A. F. Prebus & I. Zlotowski. (*Phys. Review*, 1st/15th March 1945, Vol. 67, Nos. 5/6, p. 202: abstract only.)

2752. Electron-Microscopic Examination of the Surfaces of Medical-Biological Objects by the Replica Process [hitherto reserved for Inorganic Objects].—F. Krause & H. Mahl. (*Physik. Berichte*, No. 2/3, Vol. 25, 1944, p. 105: short summary from *Kolloid-Zeitschr.*, 1943.)

2753. On the Formation of Fringes on Particles imaged in the Electron Microscope, and Their Alteration with the Optical Adjustment.—E. Ruska. (*Kolloid-Zeitschr.*, No. 1, Vol. 105, 1943, p. 43 onwards: abstract in *Physik. Berichte*, No. 2/3, Vol. 25, 1944, pp. 71–72.)

2754. A Method for Determining the Chromaticity of Fluorescent Material.—W. H. Byler & C. C. Carroll. (*Journ. Opt. Soc. Am.*, April 1945, Vol. 35, No. 4, pp. 258–260.)

2755. Vacuum-Tight Glands for Movable Spindles [Short Survey of Types described in 1934/1942 Literature].—H. Brinkman. (*Nederl. Tijdschr. Natuurk.*, May 1943, Vol. 10, No. 7/8, p. 170 onwards.)

2756. Units for Degree of Vacuum [Proposal for a New Unit based on Logarithm of the Numerical Value of the Pressure in Millimetres of Mercury].—F. H. Townsend. (*Nature*, 5th May 1945, Vol. 155, pp. 545–546.)

2757. The Use of Glass in High-Vacuum Apparatus.—R. W. Douglas. (*Journ. of Scient. Instr.*, May 1945, Vol. 22, No. 5, pp. 81–86.)

2758. Notes from the National Bureau of Standards [Advances in Plastics in 1944: Relaxation of Stresses in Annealing Glass].—(*Journ. Franklin Inst.*, March 1945, Vol. 239, No. 3, pp. 231–238.)

2759 Relaxation of Stresses in Annealing Glass [including the Derivation of an Empirical Equation representing Relaxation of Stresses in Annealing Glass].—A. Q. Tool. (*Journ. of Res. of Nat. Bur. Stds.*, Feb, 1945, Vol. 34, No. 2, pp. 199–211.)

2760. New Electro-Thermal Technique for the Union of Metal Parts to Porcelain Bodies.—A. Wahl. (*Progressus*, Oct. 1941: long illustrated summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], Jan./Feb. 1942, Electrotechnics Section, pp. 62–64.)

2761. Ceramic High Quality Condensers [Temperature Coefficient and Composition of Ceramic Dielectrics].—B. Vool & J. Skanavi. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 384: in English, summary only: in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS, Série Physique*, 1944.)

2762. Self-Healing Paper Condensers [employing a Specially Processed Metallised Paper instead of Customary Paper Tissue & Separate Metal Foil].—A. A. Hunt, Ltd. (*Wireless World*, July 1945, Vol. 51, No. 7, p. 204.)

2763. Rounded-Edge Capacitor Plates.—S. Sabaroff. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 134–136 and 268..272.)

The corona and sparkover phenomena associated with air condensers will depend, with a given voltage and spacing of the plates, upon the rounding of the edges of the plates and upon their thickness. Computations are made for optimum conditions in these respects.

2764. Contours of Capacitor Rotor Plates [Development of Equations Specifying Shape of Rotor Plates to give Constant Change of Frequency with Rotation, and Constant Rate-of-Change of Frequency with Rotation].—L. J. McDonald. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 126–127.)

2765. Silicone can Withstand Extreme Temperatures [Silastic, a New Elastic Insulating Enamel, withstands Thermal Shock and Continuous Operation at 500° F].—Dow Corning Corporation. (*Science News Letter*, 7th April 1945, Vol. 47, No. 14, p. 217.)

2766. New Heat-Resisting Plastic for Radio Parts: Cerex X214 [with Comparative Data].—Monsanto Chemical Company. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 322, 324.) *See* also 571 of 1945.

2767. On the Conversion of Titanium Dioxide [and the Production of Rutil].—F. Schossberger. (*Physik. Berichte*, No. 1, Vol. 25, 1944, pp. 22–23.)

2768. The Development of Polythene as a High-Frequency Dielectric.—W. Jackson & J. S. A. Forsyth. (*Journ. I.E.E.*, Part III, March 1945, Vol. 92, No. 17, pp. 23–31: Discussion pp. 31–37.)

Authors' summary:—"The paper is mainly concerned with the power factor of polythene (the high polymer of ethylene), which, being normally of the order of 0.00015–0.0003, renders the material highly suitable as a high-frequency dielectric. It has been found, however, that oxidation may occur during the processing of the material in the manufacture of cables and mouldings, and that this increases the power factor and may also lead to difficulties in extrusion. These effects may be virtually eliminated, however, by the use of small amounts of anti-oxidants.

"The measurable, albeit low, power factor of pure polythene is hardly concordant with the supposedly non-polar nature of the substance, and a number of possible explanations of the small basic power factor have been investigated. Measurements of power factor over wide frequency and temperature ranges show that its variation for pure polythene is extremely sluggish, but that oxidation causes the appearance of marked peaks; these observations are examined in the light of present theories of dipole loss.

"A brief account is given of the structure of polythene, and of its main physical and mechanical properties."

2769. The Dielectric Properties of Dammar and Mastic Resins.—G. N. Bhattacharya. (*Indian Journ. of Phys.*, June 1944, Vol. 18, No. 3, pp. 159–171.)

2770. The Dielectric Dispersion of a Few Natural Resins in Non-Polar Solvents.—G. N. Bhattacharya. (*Indian Journ. of Phys.*, June 1944, Vol. 18, No. 3, pp. 192–197.)

2771. Internal Discharges in Dielectrics: Their Observation and Analysis.—A. E. W. Austen & W. Hackett. (*Journ. I.E.E.*, Part I, Aug., 1944, Vol. 91, No. 44, pp. 298–312: Discussions pp. 312–322.) Summaries were dealt with in 2301 & 2714 of 1944.

2772. An Elementary Description of Some Molecular Concepts of the Structure of Dielectrics.—E. B. Moullin. (*Journ. I.E.E.*, Part I, Dec. 1944, Vol. 91, No. 48, pp. 448–455.) To be read in conjunction with Fröhlich's paper, 2773, below.

2773. Theory of Dielectric Constant and Energy Loss in Solids and Liquids.—H. Fröhlich. (*Journ. I.E.E.*, Part I, Dec. 1944, Vol. 91, No. 48, pp. 456–463.)

Described by Moullin (2772, above) as "of great practical interest to engineers since it gives them the initial framework of ideas which in time may allow insulating materials to be designed and constructed with better qualities than exist to-day."

2774. The Control, Specialised Testing, and Use of Some Modern Insulating Materials.—A. R. Dunton. (*Journ. I.E.E.*, Part I, Nov. 1943, Vol. 90, No. 35, pp. 463–470: Discussion pp. 471–473.) A summary was referred to in 2823 of 1943.

2775. New Development in the Construction of Equipment for Telecommunication Cables, with regard to the Problem of Materials [with Notes on Thermoplastics "Protodur W" & "Protodur H" as Substitutes for Lead: etc.].—R. Schulz & E. Wägele. (*Siemens Zeitschr.*, Oct./Dec. 1941: summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], March/April 1942, Electrotechnics Section pp. 95–96.)

2776. Rubbers and Their Characteristics: Real and Ideal.—L. R. G. Treloar. (*Nature*, 14th April 1945, Vol. 155, No. 3937, pp. 441–444.)

2777. Electronic Vulcanisation of Rubber may be Common.—(*See* 2861.)

2778. "A.S.T.M. Standards on Electrical Insulating Material" [Book Review].—Am. Soc. for Testing Materials. (*Electronics*, May 1944, Vol. 17, No. 5, p. 354.)

2779. New Science Developed ["Tropicalization," a New Branch of Applied Science, preventing Failure of Equipment due to Tropical Moisture & Fungus Growth].—(*Sci. News Letter*, 24th March 1945, Vol. 47, No. 12, p. 190.) Among the fungicides that have given favourable results are pentachlorophenol and salicylanilide. *Cf.* 926 of March & 1580 of May.

2780. Hermetically Sealed Transformers.—R. M. Hanson. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 136–139.)

From the Thordarson Electric Mfg. Co. "Damage by moisture absorption, fungus growth, and conductor corrosion is prevented by transformer sealing. Techniques are described, with special attention to the method of bringing out leads and testing for effectiveness of seal."

2781. Magnetism in Theory and Practice [Kelvin Lecture].—E. C. Stoner. (*Journ. I.E.E.*, Part I, Sept. 1944, Vol. 91, No. 45, pp. 340–349).—Summaries were referred to in 3596 of 1944.

2782. Magnetic Materials [Report of Lecture to I.E.E. Measurement Section].—W. L. Bragg. (*Electrician*, 25th May 1945, Vol. 134, No. 3495, pp. 467–468.)

2783. On the Magnetic Structure of Iron.—Lifshitz. (*See* 2827.)

2784. "Report on the Measurement of Surface Finish by Stylus Methods" [Survey of Technique: Application of Data to Evaluation of Finish: Book Review].—R. E.

Reason, M. R. Hopkins, & R. I. Garrod. (*Engineering*, 6th April 1945, Vol. 159, No. 4134, p. 263.)

2785. Electro-Chemical Etching [New Apparatus for marking Metal Equipment & Tools, and Its Advantages].—Griffin & Tatlock, Ltd. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 284, 286.)

2786. Electrical Contact Springs.—L. B. Hunt & H. G. Taylor. (*Journ. I.E.E.*, Part III, March 1945, Vol. 92, No. 17, pp. 38–44.)

The problem of maintaining electrical contact between parts moving relatively to each other is one of importance to the electrical industry. Suitable mechanical designs are indicated and the properties of non-ferrous metals suitable for contacts are tabulated.

2787. Electrical Contact Springs [Summary of Opening Remarks & Discussion].—L. B. Hunt & H. G. Taylor: I.E.E. Radio Section. (*Wireless World*, July 1945, Vol. 51, No. 7, p. 196.) *See* also 2786, above.

2788. Tests & Standards for Dry Batteries [History and Methods of Testing and Standardising Dry Batteries used in U.S. Army Equipments].—C. E. Skinner. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 276–284.)

2789. Wet Cell developed for Radiosonde Sets, *and* New Type High Rate Dry Cell.—U.S. Navy: S. Ruben. (*Electronic Industries*, Dec. 1944, p. 214; March 1945, Vol. 4, No. 3, p. 85.)

(i) *See* 2542, above. (ii) Compared with the battery it replaces, this Mallory Tropical Dry Cell provides 4–6 times the operating life and has a greatly increased shelf life: no technical data has been permitted to become public.

2790. D.C. Machines without Commutators [Survey of Principles & Some Patents].—M. Zorn. (Long summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], Nov./Dec. 1942, Electrotechnics Section pp. 344–346.)

2791. Gaseous Rectifier Circuits.—Chin. (*See* 2576.)

2792. Amplifier Theory Applied to Regulators.—J. M. Cage. (*See* 2573.)

2793. The Practical Side of Fine Temperature Control [Short Summary of Pamphlet Dealing Particularly with Constant-Temperature Water Baths].—L. T. Townson & R. Brock. (*Nature*, 5th May 1945, Vol. 155, p. 540.)

2794. Brazing with Pulverised Silver Alloy [Round Wires up to 0.05 Inch Diameter: Use of Mixture of Filed Silver Solder and Borax Flux].—(*Gen. Elec. Review*, April 1945, Vol. 8, No. 4, p. 60.)

STATIONS, DESIGN AND OPERATION

2795. Costs for Frequency-Modulation Stations [Data given to American Newspaper Publishers' Association].—W. J. Damm. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 280, 282.)

2796. F.M. Carrier Telephony for 230-kV Lines.—(*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 106–109.)

A frequency-modulated carrier telephone channel has been installed on a 230 kilovolt power line nearly 200 miles long. The carrier frequencies used are about 100 kc/s and wave traps are used to exclude the carrier energy from undesired channels.

2797. Broadcasting's Post-War Equipment Plans [for Modernisation of Existing Plant and Provision of Frequency-Modulated and Television Services].—"W. MacD." (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 92–93).

2798. Very High Frequency and Ultra High Frequency Signal Ranges as Limited by Noise and Co-Channel Interference.—Armstrong. (*See* 2510.)

2799. Short-Wave Broadcasting Technique: Engineering Details of the General Electric Transmitting Installations on the East and West Coasts, totalling 275 Kilowatts.—H. G. Towlson. (*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 90–94 and 132..138.)

2800. Very-High Frequency and Ultra-High-Frequency Signal Ranges as Limited by Noise and Co-Channel Interference.—Norton & Allen. (*See* 2509.)

2801. Television Relays.—H. B. Fancher. (*Communications*, Feb. 1945, Vol. 25, No. 2, pp. 58 and 69.)

A proposed 2-way relay system operating in the 2 000 Mc/s region with equipment which will deliver approximately 10 watts into an aerial system with a 6° beam: Frequency modulation with a channel width of 60 Mc/s, and a maximum modulating frequency of 10 Mc/s, is used. At each station the two receivers of each channel operate on the same frequency and the transmitters on a different single frequency.

2802. Microwave Radio Relay [Seven Relay Stations at Elevated Sites between New York and Boston for Tests of Television, Sound, and Telephone Communication by Microwaves].—(*Sci. News Letter*, 7th April 1945, Vol. 47, No. 14, p. 215.)

2803. Pulse-Time Modulation.—E. M. Deloraine & E. Labin. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 100–104.)

In the type of radio transmission described the carrier is transmitted in a series of pulses and the time interval between these pulses is varied in accordance with the modulation. The system takes advantages of the wide bandwidths available at u.h.f. and provides a high signal-to-noise ratio.

2804. Civilian "Walkie Talkie" [for the "Citizens' Radio Communication Service" 2357 of July): and Other Notes on Proposed Frequency Allocation Plan].—F. C. C. (*Sci. News Letter*, 27th Jan. 1945, Vol. 47, No. 4, p. 54.)

2805. "Talkies": Engineering Details of "Handies" and "Walkies."—(*Electronic Industries*, March 1945, Vol. 4, No. 3, p. 101.)

2806. The Para-Talkie [Small Light Transmitter-Receiver for Parachutists].—A. H. Copland. (*QST*, April 1945, Vol. 29, No. 4, p. 34.)

2807. Radio Set SCR-506: a Biography [History of U.S. Army's Highly Perfected New Medium-Range Mobile Radio Set].—A. D. Middleton. (*QST*, May 1945, Vol. 29, No. 5, pp. 11–17 and 84..98.)

2808. Rock Island Railroad Radio Tests [Discussion of Communication Problems peculiar to Railroading, such as the Necessity for Equipment Design capable of Withstanding Unusual Vibration and Shock and of Operating from a Variety of Power Supplies].—E. Dahl. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 96–102.)

2809. Carrier Current *versus* Space Radio for Railways [Experience & Equipment].—Aireon Mfg. Company. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 152..164.) "Aireon" is the new name of the Aircraft Accessories Corporation.

2810. Great Lakes Ship-Radio System.—(*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 92–97.)

The Loraine County Radio Corporation have developed over the last decade a radiotelephone service to facilitate the movement of the 600 cargo steamers on the Great Lakes. The service is automatic and employs dial operation, selective ringing, six crystal-controlled two-way channels, relay-operated transmitters, and voice-controlled terminal equipment with noise discrimination.

2811. Frequency Allocation for Multichannel Systems.—S. W. Lightman. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 120–25.)

The method described for assigning channel frequencies takes into account the response of the filter circuits, and cross-talk due to channel proximity. If all channel filters are of the same type and have similar Q factors, as is commonly the case, a solution can be developed based on an analytic allocation plan which will provide equal electrical performance on all channels and from which the problems arising from operation of any number of channels can be solved. The channels can be distributed so that harmonic interference is minimised.

2812. International Radio Frequency Proposals.—(*Electronics*, Nov. 1944, Vol. 17, No. 11, pp. 93–94.)

The consideration of the technical aspect has been assigned by the State Department to a committee under the chairmanship of J. H. Dellinger. The proposals of this Committee, as yet incomplete, include:—(1) That stations should be assigned frequencies, not wavelengths. (2) That the peak power of any radiated harmonic is to be either more than 40 db below the peak power of the fundamental or 200 milliwatts, whichever is the less. (3) That the use of damped radio-frequency oscillations should be specifically forbidden. A table of proposed radio-frequency allocations has been offered to the committee by the Inter-departmental Radio Advisory Committee (I.R.A.C.).

2813. Tropical Broadcasting: Choice of Frequencies.—T. W. Bennington. (*Wireless World*, June 1945, Vol. 51, No. 6, pp. 165–169.)

"'Longshort' wavelengths will probably be used for the purpose, and it is concluded here that, considered in the light of present knowledge, the existing channel allocations [1938 Cairo Conference] in these bands are inadequate."

2814. The F.C.C. Allocation Plan [Technical and Economic Significance of Proposal: New Services in 25 to 30 000 Mc/s Region Present Opportunities for Electronic Industry Expansion].—(*Electronics*, March 1945, Vol. 18, No. 3, pp. 92–95.)

2815. Future of Citizens' Radio Communication Service.—F.C.C. (*See* 2872.)

2816. High-Speed Radio-Telegraphy: Details of the Romac 3000 Word-per-Minute System.—S. Lalewicz, M. Konopkowa, & others. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 197–198.)

"The limitations of mechanical relays have been avoided by using wax cylinder recorders, and circuits have been developed which give a stable signal of good waveform under exceptionally severe conditions of interference and noise . . . and the methods used are such that although they were produced in the first instance for the recording of very high telegraphic speeds, they can be usefully employed for the recording of very weak signals of slow or commercial speeds." Electronic keying is employed.

2817. Frequency-Shift Radiotelegraph and Teletype System.—R. M. Sprague. (*Electronics*, Nov. 1944, Vol. 17, No. 11, pp. 126–131.)

Describes a development in the transmission of telegraph signals analogous to f.m. telephony. The transmitter maintains radiation at full power, but the carrier is shifted back and forth between two distinct frequencies to designate mark and space. The same gain in signal-to-noise ratio is obtained as in f.m. telephony without greater band-width than that required by carrier make-and-break keying. A special circuit eliminates the effect of mean frequency drift.

2818. The New Berlin Central Office for Radiotelephony.—W. Kunzel. (Illustrated summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], July/Aug. 1942, Electrotechnics Section, pp. 236–238.)

2819. Engineering Economics [Multiplex Radio Transmission].—Schlaack & Dickieson. (*See* 2585.)

GENERAL PHYSICAL ARTICLES

2820. Microwave Radiation from the Sun.—Southworth. (*See* 2534.)

2821. "Fields and Waves in Modern Radio" [Book Review].—S. Ramo & J. R. Whinnery. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 364, 366.)

2822. Wave Equation for Finite Elastic Strains [for Use in place of Classical Equation (valid only for Infinitesimal Strains) incorrectly applied to Retraction Tests of Rubber-like Materials].—A. Nadai. (*Journ. Applied Phys.*, May 1945, Vol. 16, No. 5, p. 313.) From the Westinghouse laboratories.

2823. Relationship between Nuclear Force and Gravitational Force.—K. C. Wang & H. L. Tsao. (*Nature*, 28th April 1945, Vol. 155, No. 3939, pp. 512–513.)

2824. The Torque or Rotating Action in a Beam of Light [Letter prompted by Ehrenhaft's Recent Claim: the Work of Poynting (1909), Sadowsky, & the Writer, and Beth's Experimental Results].—G. F. Hull. (*Science*, 2nd March 1945, Vol. 101, No. 2618, pp. 220–221.)

2825. On the Energy and Mechanical Relations of the Magnetic Field.—G. H. Livens. (*Phil. Mag.*, Jan. 1945, Vol. 36, No. 252, pp. 1–20.)

Attention is directed towards inconsistencies in the generally accepted theory of energy relations in the magnetic field. These inconsistencies arise when the magnetic fields due to electric currents are treated in exactly the same way as those due to magnets, and they can be avoided by treating the two types of field as being associated with different forms of energy.

"If this thesis is accepted, then we must prepare for a complete inversion of the whole of our traditional notions on this subject, that is, of course, if we admit that the claims of theoretical consistency must ultimately take precedence over those of traditional and almost universal and long-standing practice."

2826. A Historical Note on a Paradox in Electrodynamics [Concerning the Forces between Two Moving Electrons].—I. A. Robertson. (*Phil. Mag.*, Jan. 1945, Vol. 36, No. 252, pp. 32–43.)

Refers to the paradox discussed by G. W. O. Howe in *Wireless Eng.*, March 1944. (*See* 2765 of 1944. *Also* 2892 of 1941 *and Am. Journ. of Phys.*, Dec. 1942, Vol. 10, p. 302.)

2827. On the Magnetic Structure of Iron.—E. Lifshitz. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, pp. 337–346: in English.)

Author's summary:—"The shape and dimensions of the regions of spontaneous magnetisation in iron crystals are determined. It is shown that in sufficiently large crystals these regions which are in the shape of layers, should branch out towards the surface of the body."

2828. "College Physics" [Book Review].—C. E. Mendenhall, A. S. Eve, D. A. Keys, & R. M. Sutton. (*Nature*, 5th May, 1945, Vol. 155, p. 530.)

MISCELLANEOUS

2829. "Trigonometrical Tables" [Book Notice: 6-figure Tables of Logarithms, Antilogarithms and Logarithms of the Six Trigonometrical Ratios for Every Minute of Angle: Also a 6-Figure Table of Natural Trigonometrical Functions and Formulæ].—Ford Motor Company. (*Wireless Engineer*, June 1945, Vol. 22, No. 261, p. 282.)

2830. "The Simple Calculation of Electrical Transients" [Book Review].—G. W. Carter. (*BEAMA Jour.*, May 1945, Vol. 52, No. 95, p. 154.)

2831. Quality Engineering in Tube Manufacture [Testing Random Samples Indicates Deviation of Vacuum-Tube Production from Quality Standards: Dynamic Performance, Life, Mechanical, and Appearance Tests].—E. Goddess. (*Electronics*, Nov. 1944, Vol. 17, No. 11, pp. 134–137.)

2832. Quality Control in Tube Manufacture.—Goddess. (*See* 2647.)

2833. "Statistics in Government Departments" [Review of Memorandum drawn up by Institution of Professional Civil Servants for Submission to Treasury].—(*Nature*, 28th April, 1945, Vol. 155, No. 3939, pp. 522–523.)

2834. Monthly Commentary: Circuit Diagrams [and the Question of Graphical Symbols: the Important Difference between "Circuit Diagram" & the "Practical Wiring Plan"].—*Wireless World*. (*Wireless World*, July 1945, Vol. 51, No. 7, p. 193.)

"It is unnecessary, or even positively harmful, to waste time in devising a host of symbols for, say, illustrating physical differences between various types of components of the same class . . ."

2835. Timely Inventive Problems.—U.S. Navy Dept. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, p. 338.)

Among the problems for which new or improved solutions are needed are (1) transmission of rotary motion through a moisture-proof barrier; (2) small portable field-strength meter; (3) easily erected aerials up to 300 feet; (4) small aircraft-type d.c. motors without sliding contacts; (5) a "precision twin triode" for mass production; (6) a lightweight sturdy mechanical device for sequence switching; (7) a small, fast-acting, double-action solenoid.

2836. The Presentation of Technical Literature.—G. E. Williams. (*Journ. I.E.E.*, Part I, May 1944, Vol. 91, No. 41, pp. 199–202.)

"Our mental energy tends to be constant in output, so that unless the avoidable difficulties are eliminated we cannot deal efficiently with those that are inherent. It is suggested in this paper that technical authors should allow themselves to be guided by the appropriate psychological principles, the chief of which are that new knowledge ought always to be introduced in terms of what is already known, and that all important relationships should be clearly exhibited."

2837. The Work of the Papers Committee: I and II.—I.E.E. (*Journ. I.E.E.*, Part I, Sept. & Oct. 1944, Vol. 91, Nos. 45 & 46, pp. 333 & 371.)

2838. WRITING TEXTBOOKS: GUIDANCE FOR WOULD-BE AUTHORS. — "A. U. Thor." (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 203–204.)

2839. SCIENCE CURRICULUM IN POST-PRIMARY SCHOOLS. INTERIM REPORT OF A SUB-COMMITTEE OF THE ESSEX SCIENCE TEACHERS' ASSOCIATION [Short Review]. — (*Nature*, 5th May 1945, Vol. 155, p. 539.)

2840. STYLE IN ELECTRICAL ENGINEERING [including Some Remarks on Style in Lectures, Books & Papers: Faraday contrasted with Heaviside].—W. T. J. Atkins. (*Journ. I.E.E.*, Part I, Feb. 1944, Vol. 91, No. 38, pp. 80–82.)

2841. "REPORT ON THE MEASUREMENT OF SURFACE FINISH BY STYLUS METHODS" [Survey of Technique: Application of Data to Evaluation of Finish: Book Review].—R. E. Reason, M. R. Hopkins & R. I. Garrod. (*Engineering*, 6th April 1945, Vol. 159, No. 4134, p. 263.)

2842. RELAYS IN INDUSTRIAL TUBE CIRCUITS: Part III.—U. R. Furst. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 133–135.)

"Grid-controlled gas tubes operated from d.c. power provide on/off relay control. With a.c. power, the filter and method of firing the gas tube govern relay operation. The theory is extended to phototube relay control. A burglar alarm illustrates relay applications."

2843. POWER SUPPLIES FOR PHOTOELECTRIC CONTROLS [to avoid Troubles due to Undesired Modulation of the Light Source by the Mains Frequency, and to Mains Voltage Fluctuations].—D. Schulman. (*Electronics*, Feb. 1945, Vol. 18, No. 2, 177..196.)

2844. WHERE TO FIND SPECIAL INFORMATION OF ELECTRONIC USES IN INDUSTRY [Bibliography, with Complete Subject Index].—W. C. White. (*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 102–105 and 172..194.) Supplementing previous lists in the issues for June 1943 and Feb. 1944.

2845. ELECTRONIC TRACER FOR MACHINING OPERATIONS INVOLVING IRREGULAR SURFACES SUCH AS PROPELLERS, DIES, AND CAMS.—(*Electronics*, July 1944, Vol. 17, No. 7, pp. 176, 180.)

With a well-designed machine tool and an actual-size model, the contour can be duplicated within 2 or 3 thousandths of an inch when a feed speed of 20–30 inches per minute is used.

2846. HIGH-SENSITIVITY ELECTRONIC RECORDER [for Temperature or Pressure Changes, Vibration, Flow Rate, Carbon-Monoxide Concentration, Pulse-Beat Variations, etc.: Differential Phototube Device with Series of Miniature Mirrors & Lenses: Full-Scale Deflection for One-Millionth of a Microwatt, in under 1/10th Second].—General Electric Company. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 148, 150.)

2847. "ELECTRICAL ESSENTIALS OF RADIO" [Book Review].—M. Slurzberg & W. Osterheld. (*Electronics*, Nov. 1944, Vol. 17, No. 11, p. 292.)

2848. "ELECTRONICS FOR BOYS AND GIRLS" [Book Review].—J. Bendick. (*Review Scient. Instr.*, April 1945, Vol. 16, No. 4, p. 87.)

2849. "AN INTRODUCTION TO ELECTRONICS" [Book Review].—R. G. Hudson. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, p. 349.) Author's intention is to explain the "science of electronics and its modern applications in terms . . . understandable and useful to those with only an elementary knowledge of mathematics and physics."

2850. "COMMUNICATION CIRCUITS" [Book Review].—L. A. Ware & H. R. Reed. (*Electronics*, Nov. 1944, Vol. 17, No. 11, p. 294.)

2851. THE FUTURE OF THE DOMESTIC WIRING INSTALLATION: Part I—IMMEDIATE DEVELOPMENTS: Part II—THE DISTANT VIEW.—Forbes Jackson & W. J. H. Wood: G. Smith & E. Jacobi. (*Journ. I.E.E.*, Part II, Dec. 1943, Vol. 90, No. 18, pp. 453–466: Discussion pp. 466–476.)

2852. HIGH-FREQUENCY HEATING [Discussion organised by Birlec, Ltd.].—T. G. Tanner & others. (*Electrician*, 18th May 1945, Vol. 134, No. 3494, p. 437: short summary only.)

2853. ESSAY IN RADIO-FREQUENCY HEATING.—Macnamara & Greatorex. (*See* 2645.)

2854. FIELDS OF AIR-CORE COILS AND APPLICATIONS TO RADIO-FREQUENCY HEATING [Summarised & Modified Version of "the Most Important Parts" of Kirkpatrick's Paper (3412 of 1943)].—G. H. Brown: C. B. Kirkpatrick. (*Electronics*, June 1944, Vol. 17, No. 6, pp. 234..258.)

2855. SHIELDING DIELECTRIC HEATING INSTALLATIONS [Results of Field Measurements made on a Typical Dielectric Heating Installation].—G. W. Klingaman & G. H. Williams. (*Electronics*, March 1945, Vol. 18, No. 3, pp. 334, 336, 338, Report of I.R.E. 1945 Winter Technical Meeting.)

2856. SHIELDING OF DIELECTRIC HEATING INSTALLATIONS.—G. W. Klingaman & G. H. Williams. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 106–109.)

"Field intensity measurements in the vicinity of a 9 Mc/s electronic generator show effects of various shields, grounding arrangements and line filters on radiation when feeding 6 kW into a dummy load."

The points of radiation leakage are detected by an instrument consisting of a small shielded loop coupled to an oscillating wavemeter which provides indications on a grid meter for strong signals and by heterodyne beat in headphones for weaker signals.

2857. APPLICATION OF HIGH-FREQUENCY PHENOMENA IN MEDICINE [For Diathermy].—

(*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 286–294.)

2858. DIATHERMY PROBLEMS: STUDY OF INTERFERENCE REDUCTION.—(*See* 2610.)

2859. EXCHANGE OF DIAGRAMS & DATA BETWEEN RADIO THERAPY CENTRES.—(*Nature*, 28th April 1945, Vol. 155, No. 3939, p. 508.)

2860. INDUSTRIAL AND MEDICAL RADIOLOGY: A REVIEW OF PROGRESS.—B. J. Leggett. (*Journ. I.E.E.*, Part I, Nov. 1944, Vol. 91, No. 47, pp. 407–421.)

2861. ELECTRONIC VULCANISATION OF RUBBER MAY BE COMMON [Patent for Uniformly Heating the Rubber and Sulphur Mixture Electronically: Time for Vulcanisation reduced to a Fraction of that Required with Steam Heating].—(*Science News Letter*, 31st March 1945, Vol. 47, No. 13, p. 207.) French and Swiss discoveries used in patents of the Goodrich and Firestone Companies.

2862. MEASURING POTENTIALS IN GROWING THINGS ["Every Plant appears to have an Electrical Pattern, and Living Cells a Field that may determine Their Growth": New Impetus to the Northrup–Burr Theory of the Electrodynamic Basis of Living Things: the Rotating Salamander as a Sinusoidal A.C. Generator: etc.].—H. T. Stetson: H. S. Burr. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 82–85 and 180, 181.)

2863. MAGNETIC SEPARATION OF PURE IRON PARTICLES [Patent for Heating Metal to Critical Temperature at which Carbon-Containing Iron becomes much less Magnetic than Pure Iron so Permitting Magnetic Separation].—(*Science News Letter*, 31st March 1945, Vol. 47, No. 13, p. 197.)

2864. ELECTRONIC INSPECTION OF MAGNETIC MATERIALS [U.S.S.R. Defectoscope for Railway-Rail Testing (Special Valve forming Inertialess Detector, permitting Testing at Speeds of 10–25 km/hour].—(*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 164..177.) *Cf.* Gorelik, 3364 of 1944.

2865. A NEW FRENCH METHOD FOR STEREOSCOPIC CINEMA PROJECTION ["Cyclostereoscope"].—Savoy. (*See* 2692.)

2866. SPATIAL IMPRESSION OF A PLANE IMAGE BY MONOCULAR OBSERVATION.—Kogel. (*See* 2691.)

2867. A NEW METHOD OF MAKING LARGE MIRROR PARABOLOIDS FOR THE INDUSTRIAL UTILIZATION OF SOLAR ENERGY [Parabolic Mirrors formed of Silvered Glass Plates either Cemented on to Concrete Moulds or Glued to Plywood Supports: Focal lengths of the Order of 1 metre and Chord 1.5 metres: Efficient Utilization of Solar Heat Demonstrated Experimentally].—F. Molero. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 1944, Vol. 45, No. 1, pp. 14–18: in English.)

2868. FLUORESCENT CRACK DETECTION [and the Metrolux Inspection Cabinet: for Metals, Plastics, Ceramics, Glass/Metal Seals, etc.].—Metropolitan-Vickers Company. (*Electrician*, 11th May 1945, Vol. 134, No. 3493, p. 426.)

2869. MOULD AND HUMIDITY IN RADIO AND SIGNALS EQUIPMENT.—C. P. Healy & J. C. Niven. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, pp. 300–306.)

Radio equipment built by pre-war methods does not operate satisfactorily at high ambient temperature and relative humidity, due inter alia to mould growth. Fungicides may be used to combat this but it is preferable to use materials which do not support mould growth, rather than to attempt to render poorer grades tropic proof.

2870. FUNGUS AND MOISTURE PROTECTION.—R. Proskauer & H. E. Smith. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 119–123.)

Discussion on the treatment of equipment to permit operation under climatic extremes, with consideration of surface conditions, qualities of finish, and fungistatic values. Most vulnerable materials are:—Cellulose, cement, cordage, cotton, felt, glue, leather, paints, phenolics, paper, varnish, varnished cambric and waxes (most). Less vulnerable:—Melamine, rubber (natural and synthetic), and waxes (micro-crystalline). Least vulnerable:—Glass (clean), glass fibre, inorganics, polystyrene and polyvinylidene chloride.

2871. THE F.C.C. ALLOCATION PLAN [Technical and Economic Significance of Proposal: New Services in 25 to 30 000 Mc/s Region Present Opportunities for Electronic Industry Expansion].—(*Electronics*, March 1945, Vol. 18, No. 3, pp. 92–95.)

2872. FUTURE OF CITIZENS' RADIO COMMUNICATION SERVICE.—F.C.C. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 194..210.)

A discussion of the F.C.C. proposal to allocate the 460–470 Mc/s band for private civilian use.

2873. INTERNATIONAL RADIO FREQUENCY PROPOSALS. (*See* 2812.)

2874. I.R.E. STAGES LARGEST TECHNICAL MEETING: SUMMARIES OF SOME OF THE PAPERS.—I. R. E. (*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 86–94 and 196..203.)

2875. RADIO PROSPECTS: POST-WAR JOBS FOR TECHNICIANS.—H. A. Hartley. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 199–201.)

A somewhat gloomy analysis. In a concluding instalment the author will make suggestions for the peacetime reorganisation of the radio industry.

2876. SYNTHETIC TRAINING FOR AIRCREWS: AERIAL NAVIGATION BY WIRELESS PRACTISED ON THE GROUND BY ARTIFICIAL AIDS.—Rediffusion, Ltd. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 205–207.)